Journal of Chemical Education

Published by

Division of Chemical Education of The American Chemical Society

Easton, Pa.

Entered as Second-class Matter, January 31, 1924, at the Post Office at Easton, Pa., under the Act of March 3, 1859. Accepted for mailing, at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924.

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UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Associate Agricultural Chemist.

Applications must be on file at Washington, D. C., not later than February 21st. The examination is to fill a vacancy in the office of Experiment Stations, Department of Agriculture, and vacancies occurring in positions requiring similar qualifications.

The entrance salary is $3000 a year. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions.

The major duties of the position are the preparation of technical abstracts for the Experiment Station Record of current scientific literature on soils, fertilizers, and agricultural and biological chemistry, and reviews of the progress in and special articles on research in these fields.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience; and writings to be filed with the application.

Full information and application blanks may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post-office or customhouse in any city.

Metric System Convenient for Big and Little. How the metric system may be conveniently used for measurements from the infinitely small confines of the atoms of which all matter is made up to the inconceivably great distances separating the stars from each other, was explained at the American Association for the Advancement of Science meeting by Dr. Alexander McAdie, of Harvard University.

Using the meter, to equal 39.37 inches, as the unit, Dr. McAdie explained that the total range of measurements in the universe as we know it ranges from a thousand million million million meters for stellar distances down to a thousand million million millionth of a meter for the distances separating the electrons which make up the atoms.—*Science Service*

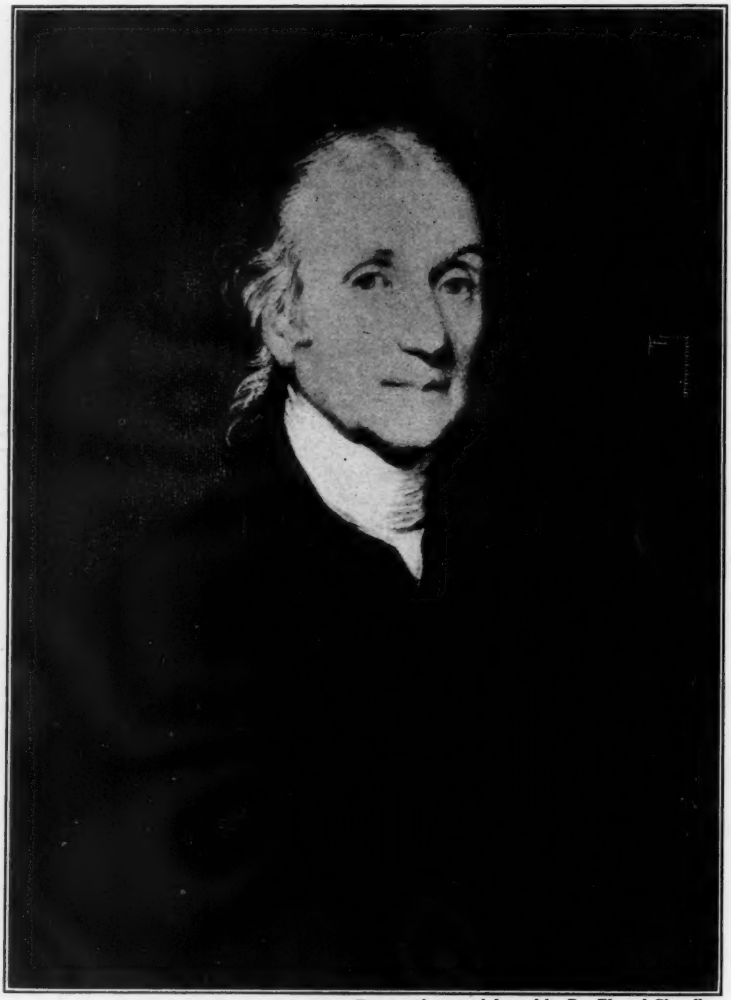
Student's Viewpoint Should Be Considered. The value of viewing curricula from the pupil's standpoint was pointed out by Dr. Jesse E. Adams of the University of Kentucky who addressed the American Association for the Advancement of Science.

"It has begun to dawn upon us that the attitudes and ideals built up when pupils must take subjects they do not like may be far more detrimental than all the subject-matter they get," he said.

"It would seem that those who are responsible for making our curricula should be fully cognizant of how deadening failures are and to what extent forced interests burn the candle at both ends. I believe Otis Caldwell was quite right when he said: 'Pupils develop fastest when engaged most of their time upon things in which they succeed and not fail.'"

Dr. Adams' interest in the viewpoint of the students led him to make a survey of high-school pupils in Kentucky. Five thousand pupils answered such questions as: What were the subjects in which you failed? What subjects would you like out of the curriculum and what subjects would you like to take that you cannot get?

It was found that mathematics and Latin were responsible for by far the greatest percentage of the failures. The difficulty and lack of practical application of these subjects made them very unpopular. Algebra, geometry, and Latin were wanted out of the curriculum. Of the subjects which the pupils wanted to take and could not get, the girls agreed upon domestic science, French, Spanish, typewriting and bookkeeping, and the boys upon manual training, chemistry, typewriting and bookkeeping.—*Science Service*



From a photograph loaned by Dr. Elwood Chandler

THE STUART PORTRAIT OF PRIESTLEY

EDITOR'S OUTLOOK

A Priestley Number

THE semi-centennial meeting of the American Chemical Society at Philadelphia last September offered many chemists their first opportunity to visit the home of Joseph Priestley at Northumberland and afforded a convenient and appropriate occasion for the dedication of the Priestley Memorial. The members of the Society are doubly bound to the Northumberland shrine, for it was there that the organization had its birth.

The dedicatory exercises at the Priestley home and the meeting of the Section of History of Chemistry were productive of a number of good Priestley papers and it seemed appropriate that these and one or two others be published together in a Priestley number of the JOURNAL. The present issue is the outcome of that suggestion. Appropriately enough it appears during the month which marks the anniversary of his death, February 6, 1804.

We wish to acknowledge our great indebtedness to Dr. Gerald L. Wendt of Pennsylvania State College for his invaluable assistance in the collection of illustrations for this number and to thank those others whose loans are acknowledged elsewhere.

While there is necessarily a certain lack of unity in any collection of this kind and some unavoidable overlapping, we believe that the group of papers here presented furnishes the teacher with material for the development of an excellent background for a discussion of Priestley's contributions to chemistry. The good doctor's amazing versatility and insatiable intellectual curiosity are portrayed in the breadth of his scientific studies and investigations but they carried him into many other fields as well. A teacher by natural inclination and, for many years, by occupation, he had definite and quite advanced views on education. No doubt the fact that his thinking so far outstripped the general thought of his age and earned for him the reputation of being a heretic not only in religion but in other subjects also, accounts for the scant attention paid his ideas at that time. Many of the principles restated by Spencer and which influence our system of education today are set forth in Priestley's essays. Teachers of chemistry may find much to admire in Priestley, the educator as well as in Priestley, the chemist.

The Electronic Concept

THERE is inevitably a lag between the discovery of new facts and principles in science and the incorporation of those facts and principles into courses of instruction. Sometimes, however, the lag is so unduly prolonged as to justify a suspicion that it arises fully as much from mental inertia on the part of instructors as from inherent and unavoidable difficulties. It appears to us that this is true in the case of the application of our

present-day knowledge of the structure of matter in the teaching of general chemistry.

True, many text-books have been slow to include the newer knowledge and to utilize it in the explanation and correlation of phenomena. Yet the blame cannot be laid entirely upon the producers of texts, for authors and publishers unite in the charge that books which emphasize the electronic concept constitute too radical a departure from past custom to find favor in the sight of the majority of teachers.

We believe that a great deal of the apathy and, in some cases, active hostility to the adoption of the electronic concept in teaching is a reflection of ignorance on the part of teachers. Many instructors, unfamiliar with the actual extent of present knowledge, dismiss the matter with the comment that it is "all theory, anyway." Others who have not taken the trouble to clarify their own thinking feel that what puzzles them must necessarily be even more confusing to immature students, and object to introducing such unnecessary complications into their courses.

There is some excuse for such an attitude on the part of many high-school teachers, at least. Heavy teaching schedules and, often, the necessity of teaching other subjects in addition to chemistry, leave little opportunity for the study necessary to keep abreast of contemporary developments and to revise teaching practice in accordance therewith. If the teacher gives up the hopeless task of searching the literature and turns to available books on the structure of matter he often finds himself involved in a mass of technical detail which discourages rather than enlightens him.

For these reasons we have felt that it would be an excellent thing to furnish busy teachers with a brief summary of present-day knowledge in this field. Such a summary was prepared for the JOURNAL by Dr. Huggins and the publication thereof is completed with the appearance of the fifth article of the series in this issue.

Dr. Huggins has done a notable service to teachers of chemistry in thus bringing into readily available and usable form the essential facts of material structure. He has shown that the modern theories are based upon well-proved facts and has demonstrated in the handling of his subject-matter that it can be presented clearly and without confusion even to high-school students. As Dr. Huggins, himself, points out there is room for difference of opinion as to how much of this material may profitably be included in a general chemistry course. It should be apparent, however, to all who have carefully followed this series of articles that teaching which fails to take the electronic concept into account is not only archaic in its deficiency but is apt to be at times actually contrary to fact.

When books on popular science, periodicals of the more serious type, and even the daily newspapers are filled with references to the electron, how can we claim that we are doing our duty by our students in the matter of furnishing them with a basis for intelligent interest in the achievements of science if we neglect to tell them that such a thing as an electron exists? When all the laws of chemical combination are traceable to the structure of the atom, how can we maintain that we are imparting a knowledge of chemical principles if we neglect the most fundamental principle of all?

This latter point is one which we believe should be further emphasized. If the structure of matter were but one more rather difficult topic to be added to an already crowded syllabus, the objectors could make a very good case for themselves. But we are not pleading for a mere *addition* to the course; we advocate a revised treatment throughout, in terms of modern thought. The teacher who attacks the subject from this angle will soon discover that the initial outlay in time and effort necessary to impart the essentials of atomic structure will pay for itself many times over in a more thorough understanding and a better organization of chemical subject-matter. Once mastered, the electronic concept dispels many dark mysteries and relates many hitherto disconnected phenomena. It raises chemistry from a semi-empirical to a truly scientific basis.

Fellowships

WE SHOULD have stated in the January number that the list of "Positions Open to Graduate Students Majoring in Chemistry in Various Colleges and Universities" made no pretensions to being a complete roster of available openings. Dr. William McPherson compiled the list from replies received in answer to inquiries sent to the members of the American Association of Universities. Information was received from all members except three. Data at hand for several other institutions were added.

It has been suggested that a supplementary list be published. We should be very glad to include in such a list all institutions which can furnish us with the necessary information not later than February 25th. This will enable us to place the supplementary roster in the March number of the JOURNAL.

Spring Meeting

THE American Chemical Society will hold its seventy-third meeting at Richmond, Virginia, April 11th–16th with headquarters at the Jefferson Hotel.

Those who are planning to attend should reserve hotel accommodations as soon as possible. William G. Crockett, Medical College of Virginia, Richmond, Virginia, Chairman of the Hotel Committee, will be glad to assist any who experience difficulty in making hotel reservations.

As usual the railroads have granted a reduced fare to and from the meeting. In order to take advantage of the reduction allowed, an identification certificate must be obtained from the Secretary of the Society or from the Secretary of the Local Section and presented at the ticket office window. Tickets may be purchased April 7th–13th and will be good returning until midnight April 22nd.

Authors who are to present papers before the Division of Chemical Education should make sure that their titles are in the hands of the Secretary, Ross A. Baker, Bowne Hall, Syracuse University, Syracuse, N. Y., not later than March 5th. They should also state whether or not they will require the use of a lantern. Abstracts, preferably not over one hundred words in length, should accompany the titles. It is necessary that the titles be submitted by the time stated in order that they may be printed in the final program of the meeting. By vote of the Council no papers may be presented at the meeting, titles for which are not printed on the final program.

The Division of Chemical Education will join with the Division of Organic Chemistry in a Symposium on the "Teaching of Organic Chemistry" and will meet one-half day with the History of Chemistry Section. At one session the question of coöperation of the Local Sections with the teachers of chemistry will be discussed. The Chairmen and Secretaries of the Local Sections are especially invited to be present at this session.

The Senate of Chemical Education will meet in the Flemish Room of the Jefferson Hotel at nine o'clock, Tuesday morning, April 12th.

THE BIRTH OF THE AMERICAN CHEMICAL SOCIETY AT THE PRIESTLEY HOUSE IN 1874*

S. A. GOLDSCHMIDT, NELHOLME, WOODSTOCK, VERMONT

This is the age of memoirs, reminiscences, and recollections. Publishers' catalogs are filled with titles whose numbers are scarcely surpassed by those of novels. I have sometimes wondered how authors could write so many details of the past, unless they commenced note-books at the time of their birth.

It is only when I endeavor to recall the happenings at the centennial celebration of the discovery of oxygen, that I realize how difficult it is not to allow recollections to be affected by imagination in order to make them interesting.

You well know, how, in April, 1874, Dr. H. Carrington Bolton, an instructor in the Columbia University School of Mines, suggested a commemoration of this event, on which was laid the foundation of modern chemistry.

To this, Professor Rachel L. Bodley of the Women's Medical College of Pennsylvania, added that of holding it here at Northumberland, Pa., where Priestley passed the latter days of his life.

A circular, signed by thirty-seven leading chemists of the day, was sent to all thought to be interested in chemistry, calling a meeting to be held on July 31st and Aug. 1st, the latter being "Oxygen Day."

The meeting was attended by seventy-seven chemists, some with ladies, many of whom were the leaders in the profession in this country. Others present hoped to follow in their steps and attain a similar reputation, an ambition which, perhaps, may have been easier to achieve with the then limited number than at present, when the American Chemical Society alone numbers thousands on its roll.

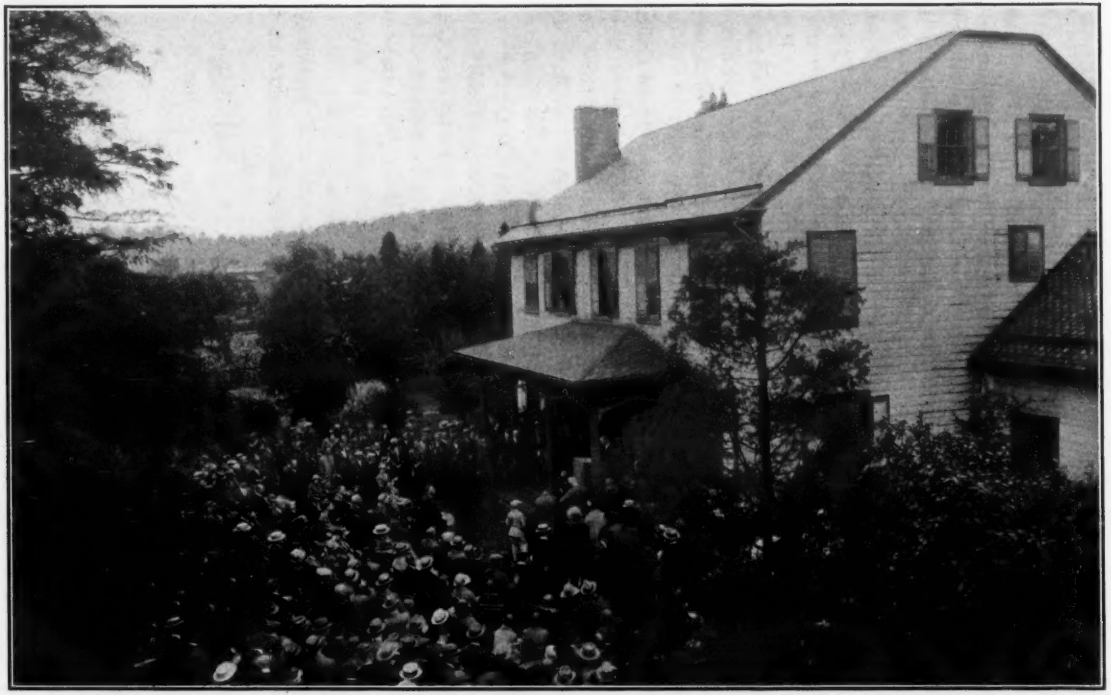
Then a chemist was supposed to have almost universal knowledge, but scientific advance has been so rapid that now one is fortunate to be able to know a single branch well.

The meeting, after a welcoming address by Col. David Taggart of this town, was organized by the election of Dr. Chas. F. Chandler as chairman and thirteen of the most distinguished chemists of the country as vice presidents.

Dr. Chandler, the leader among the younger men, though only thirty-eight, had already made a reputation on the continent second to none, a reputation which lasted until his death last August.

During the two-days' session, papers were read by H. H. Croft, "The Life and Labors of Priestley," T. Sterry Hunt, "The Century's Progress in

* Remarks at the dedication of the Joseph Priestley memorial, Northumberland, Pa., September 5, 1926.



Dedication of the Joseph Priestley Memorial, September 5, 1926. Taken from the roof of the Museum; Dr. Charles A. Browne speaking.

Theoretical Chemistry," J. Lawrence Smith, "A Review of Industrial Chemistry," Benjamin Silliman, "American Contributions to Chemistry." The eulogy, delivered by Henry Coppée at the grave on the hill overlooking the beautiful Susquehanna, closed the evening of the first day. These addresses, with an account of the proceedings, were published in the *American Chemist*, a journal upon which was laid the foundation of the great publication of the present Society.

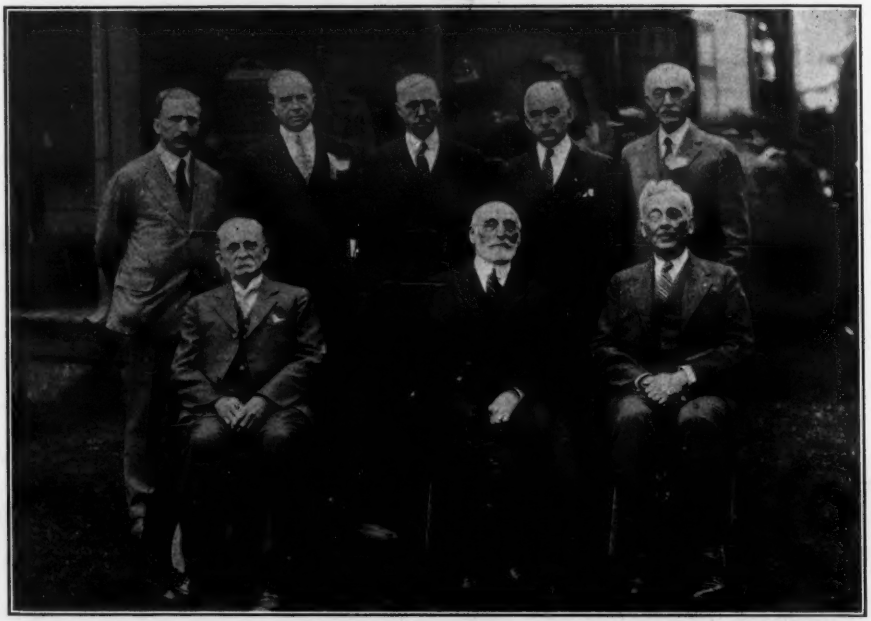
On the second day was advanced the suggestion of forming an American Chemical Society. Such an organization was opposed, by several prominent men, on the ground that there were not enough chemists, and probably never would be, in the United States to support such a society. This, perhaps, might have proved true had it not been for the unwearied effort of Dr. Chandler. At his instance another circular was issued in January, 1876, in which the formation of a local New York City association was suggested. The response was so hearty that those present at a meeting in April of the same year decided to start an American Chemical Society to cover the entire country and possibly Canada. The history of its subsequent vicissitudes and final success belongs to the narration of others.

It is not difficult, however, to recall the unbounded hospitality of the citizens of Northumberland. Every house was opened to the visitors; nothing was left undone to minister to their comfort.

As a slight acknowledgment of these courtesies, photographs of the events and an album with an address signed by those present was placed in the Priestley house, then occupied by his descendants, and now, thanks to the generosity of the chemical alumni of Pennsylvania State College, converted into a permanent memorial by the erection of the fireproof museum dedicated today.

I am, personally, glad that in calling the present meeting the chemical department of Pennsylvania State has violated the resolution which adjourned the Centennial celebration to 1974, as it enables one of the three survivors of 1874 to again see this beautiful spot and to convey to the descendants of our entertainers a slight appreciation of the kindness of their parents.

Small Crystals Regulate Big Radio Stations. Quartz crystals, now extensively used in controlling the wave-length of radio broadcasting stations to keep the length constant, may now be available for long wave commercial stations, as a result of experiments by J. R. Harrison, assistant in physics at Wesleyan University, Middletown, Conn. Formerly, for long waves it was necessary to use large crystals so that they would vibrate with the proper frequency, but Mr. Harrison has found a type of mounting in which the electrical field is applied in a way that causes the crystals to vibrate more slowly than it ordinarily does, he explained at the meeting of the American Physical Society in Philadelphia recently.—*Science Service*



SPEAKERS AT THE DEDICATION OF THE JOSEPH PRIESTLEY MUSEUM, SEPTEMBER 5, 1926

Front, from left to right—A. A. Brenneman '66; Dr. S. A. Goldschmidt, surviving members of group present at meeting in 1874 at Priestley home, when American Chemical Society was organized; and James F. Norris, President, American Chemical Society. Back, from left to right—Dr. G. L. Wendt, Dean of Chemistry and Physics; William H. Teas '97, Chairman of the meeting; Dr. C. A. Browne, Chairman American Chemical Society Committee; Dr. William H. Walker '90, representing G. G. Pond Memorial Association; Rev. Dr. H. R. Bender.

DESCENDANTS OF JOSEPH PRIESTLEY AT THE DEDICATION OF JOSEPH PRIESTLEY MEMORIAL, SEPTEMBER 5, 1926

Front, left to right—Mrs. Sally Stearns, Mrs. Jennie Campbell, Mrs. Fannie Hays, Mrs. Frances Forsythe, Mrs. Fannie Tulmin. Second row, left to right—Miss Virginia Lyon, Miss Florence Lyon, Mr. Thos. Stearns, Miss Elizabeth Frazier, Mrs. Elizabeth Frazier, Miss Jane Frazier, Miss Marion Frazier (directly in front of Mrs. Frazier), Miss Margaret Lyon. Third row, left to right—Dr. Edward Lyon, Dr. Joseph Priestley (hidden behind Mr. Thos. Stearns), Mr. George Lyon, Mr. Edward Lyon.

HISTORY OF THE PRIESTLEY HOUSE AND THE MOVEMENT FOR ITS PRESERVATION*

WILLIAM H. WALKER, CONSULTING CHEMICAL ENGINEER, BRIDGTON, MAINE

About the first of August, 1794, Dr. Joseph Priestley, after a long and tiresome journey from England, arrived in Northumberland. His fame as a clergyman and a scientist had preceded him to America and he was royally entertained in both New York and Philadelphia as he passed through those cities. But he longed for the quiet and rest of the country and so pushed on to Northumberland with the purpose of visiting his son who had settled there a year or so before. He was, however, so pleased with the town and its surroundings that he quickly decided to make Northumberland his home and wrote to a friend in England under date of August 27th, "I have just now fixed upon a spot on which to build a home." He states in another letter that, "Nothing can be more delightful nor more healthy than this place," and in the diary of William Davy, then living in Sunbury, we read, "Dr. Priestley visited us at Sunbury. He is in the whole so well pleased that he is preparing to build a very good brick house, the foundation of which, and a well, he has already dug." This was on October 3rd, indicating that the good Doctor lost little time in making up his mind where and how he was to live.

Northumberland is one hundred thirty miles from Philadelphia and, in 1794, four days were required to make the journey up the valley of the Schuylkill, over the divide, and down to the Susquehanna. It is rather remarkable that Priestley should have selected a home so far away from Philadelphia, the great center of commercial, social, and political activity. George Washington was President of the United States and, with Congress, was living there. Dr. Priestley writes of having taken tea with President Washington and that: "He (Washington) invited me to come at any time without ceremony."

Having once chosen his home he seems never to have contemplated a change. On account of his remoteness from a large center he encountered difficulties in obtaining carpenters. On April 5, 1795, he writes to England, "Nothing is yet done towards building my house. It is next to impossible to get workmen and the price of everything is advanced one-third since we have come hither." In May of the same year he writes, "I cannot make many experiments to much advantage till I get into the house I am about to build. At present I have both my library and apparatus in one room in my son's house."

Apparently nothing of moment was done during this entire summer,

* Read at the meeting on the lawn of Joseph Priestley's house, Northumberland, Pa., September 5, 1926, as a part of the exercises connected with the pilgrimage made by chemists during the golden jubilee of the American Chemical Society.

for on September 14, 1795, one year after he planned to build, he writes, "We have had an uncommonly wet and unhealthy summer all over the continent.....On this account we have not been able to make bricks to build my house." Evidently he now changed his plans and determined to build a frame house. He had only freshly sawed lumber but this he prepared as follows:

> To kiln dry boards we dig a trench about 2 feet deep, the length of the boards and what breadth you please. We then support the boards with the edges downwards and so that when the fire is made under them, the smoke and heat may have access to every part of them. Two or three stages are placed one over another and on the outside, boards to keep off the rain. In ten days they will be as much dried as by exposure to the air in two years. We commonly kiln dry ten thousand feet at a time. The fire wood must be such as is not apt to flame, lest the boards should take fire, which sometimes happens. The expense cannot be much. A house constructed with such boards I prefer to one of brick or stone.

He looked forward anxiously to the completion of his house for in October, 1795, he writes, "I promise myself, when my house and laboratory shall be erected, to devote as much time to philosophical pursuits as ever I have done. Hitherto it has not been in my power to do much, as I have only one room in my son's house for my library and apparatus too." And again in December, "I have much more to do in my laboratory, but I am under the necessity of shutting up for the winter, as the frost will make it impossible to keep my water fit for use, without such provision as I cannot make till I get my own laboratory prepared on purpose, when I hope to be able to work alike, winter and summer."

However, the building must have progressed very slowly, for on July 28, 1796, two years after reaching Northumberland, he writes, "My house will not be finished until next Mid-summer: but I hope to get the laboratory finished soon." In September of this year Mrs. Priestley died. He writes on September 19, 1796, "This day I bury my wife. She died on Saturday, after an illness of a fortnight.....She had taken much thought in planning the new house and now that it is far advanced and promises to be everything she wished, she is removed to another."

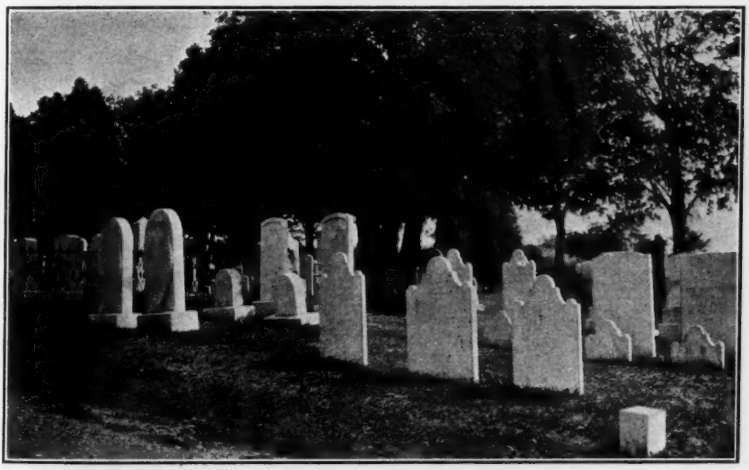
In the following year the house and laboratory were finished. Dr. Priestley's son writes in completing his father's memoirs,

> Towards the end of 1797, and not before, his LABORATORY and LIBRARY were finished. None but men devoted to literature can imagine the pleasure he derived from being able to renew his experiments with every possible convenience and from having his books once more arranged. His house was situated in a garden, commanding a prospect equal, if not superior, to any on the river Susquehanna, so justly celebrated for the picturesque views its banks afford. It was a singular fortunate circumstance that he found at Northumberland several excellent workmen in metals who could repair his instruments, make all the new articles he wanted in the course of his experimenting, as well as, if not in some respects better than he could have got them done in Birmingham.

By A. L. Kocher in the *Architectural Journal*

ARCHITECT'S DRAWING OF THE PRIESTLEY HOUSE

Priestley thoroughly enjoyed his house, his laboratory, and his garden. Concerning the latter he wrote, "Plants, as well as other objects, engage more of my attention than they ever did before.....I wish I knew a little more botany; but old as I am, I learn something new continually." One can readily imagine the dear old man—for such he surely was—stepping from his study or his laboratory after a morning of earnest work to labor among his flowers; or possibly, to wander under the trees which bordered the river; or perhaps, to sit a while on the bank and watch the then limpid waters of the Susquehanna flow onward to the sea. Here



The Priestley Burial Lot, Northumberland, Pa.
Photograph, 1921, by Dr. Louise McDanell Browne. Joseph Priestley's headstone is the central one of the three aligned in the foreground.

he lived and worked until February 6, 1804, when he peacefully passed away. From this house he was borne to the grave we have just visited, where of himself his epitaph says, "Return unto thy rest, O My Soul, for the Lord hath dealt bountifully with thee."

* * * *

Fifty miles across the mountains to the west of Northumberland lies the Pennsylvania State College. Here dwelt for many years Doctor George Gilbert Pond, professor of chemistry and dean of the School of Natural Sciences. A profound admirer of Doctor Priestley and always greatly interested in the history of chemistry and physics, Doctor Pond, early in his life at State College, sought out Northumberland and this venerable home of Priestley.

Dr. Pond frequently spoke of the lamentable condition into which the Priestley house and grounds had fallen, and noted with deep regret the slow but sure disintegration of the old place, hallowed as it is by the memories of an illustrious past. At several times he formulated plans for the purchase and restoration of the property, but there were never sufficient funds in sight to make such a move possible.

Then came the World War, crowding into the background all activities not connected with support of the Government. However, in 1919, two events happened which in Dr. Pond's mind made some action regarding the Priestley Homestead imperative. One was the fact that the house was being used as a boarding house for foreign laborers and

THE PRIESTLEY HOUSE BEFORE ITS RESTORATION
Photograph by Dr. Louise McDanell Browne. The two tall hemlocks are said to have been planted by Dr. Priestley himself.

was, more rapidly than ever before, going to its ruin; and second, a report was circulated that a new railroad location in the valley of the Susquehanna passed through the Priestley property and would necessitate the destruction of the house.

Dr. Pond realizing that something had to be done, moved with his accustomed energy and directness and presented a plan to the Chemical Alumni of the Pennsylvania State College by which the old house could be saved to future generations. The presentation of his plan took the form of a dream in which he saw the house taken down in units and moved and re-erected on the Campus of the Pennsylvania State College. His understanding then was that the Priestley grounds were to be sacrificed

in any case, and that removal to State College was a certain way of insuring the perpetual care of at least the house.

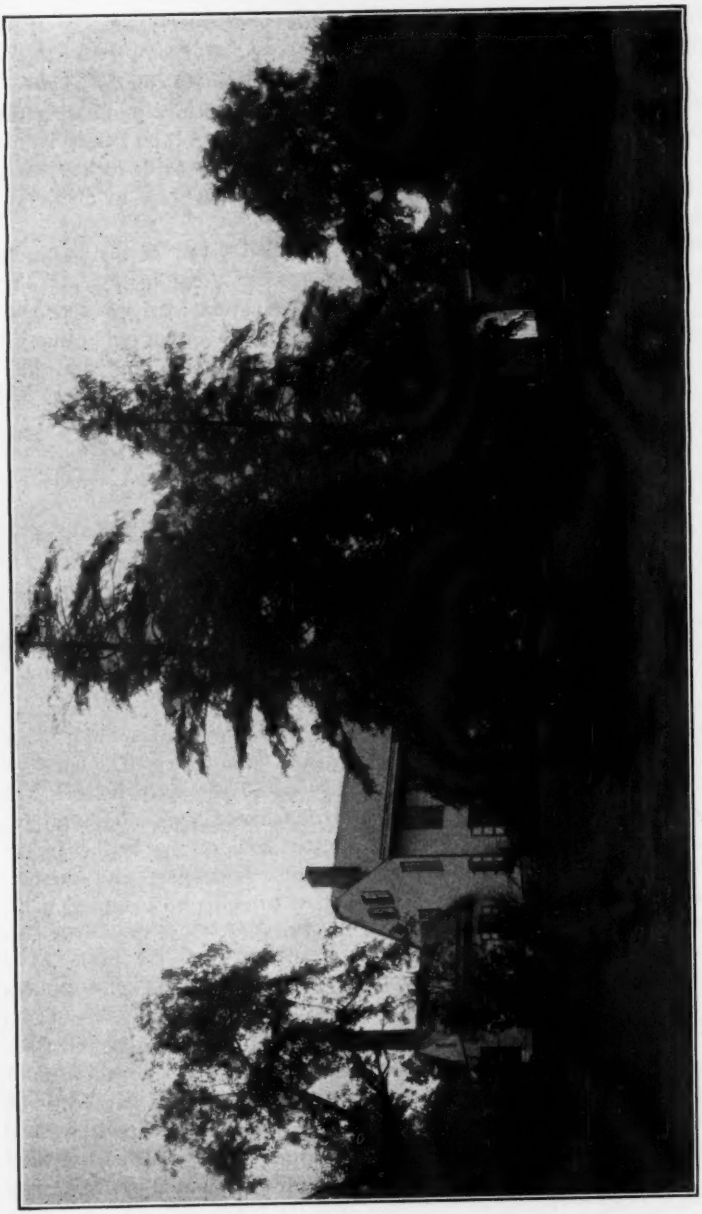
Dr. Pond suggested to "his boys," as he was wont to call the Chemical Alumni, that a fund should be raised for the purpose of purchasing the house, and moving and re-erecting it. The Trustees of the Pennsylvania State College had already expressed a willingness to provide for perpetual care of the house when on the campus, but no funds were available for placing it there.

Notwithstanding the fact that everyone had given of his resources during the War until it had hurt, the response was exceedingly gratifying. However, before the fund was complete, Dr. Pond received a printed notice stating that the house and grounds were to be sold at public auction at a date just ten days later. Through the very prompt and splendidly generous support of Mr. William H. Teas of Marion, Virginia, Dr. Pond was enabled to appear at the auction with funds that assured to him the purchase of the property. Thus was the legal title to the Priestley house and grounds acquired by the Chemical Alumni of the Pennsylvania State College through the prompt and generous action of these two men.

Plans for the restoration of the house and for a fund large enough to carry them out were well formulated when Dr. Pond very suddenly died in May, 1920. When we recovered from the shock of this sad event, we recognized with dismay that the light which had illumined the picture had gone out; and that the driving force to which action in the past had been due, was no longer present. For a time the project stood still.

We then recalled the query from Gray's Elegy, "Can storied urn or animated bust, back to its mansion call this fleeting breath?" No, they cannot, but a storied urn has its function, its purpose, its utility. The Trustees of the Pennsylvania State College promptly honored the memory of Dr. Pond by giving his name to the new Chemical Laboratory, then building. But a more personal testimonial of the loving regard in which Dr. Pond was held by his students, both past and present, seemed desirable; and in the possibility of bringing to completion his cherished plan for the preservation of the Priestley house there was presented the looked-for opportunity.

The work was then taken up where Dr. Pond had laid it down. In the meantime there had developed two facts which made a change in the plan necessary. First, a closer inspection of the house showed that, because of its age, but little of the structure could be moved without almost complete destruction. Second, the project to push an additional railroad through the property had been abandoned. Hence it seemed best to restore the house and the grounds amid all the traditions of their early years, retaining the very trees which had been planted by Dr. Priestley so long ago. Only those who had seen the house and grounds before



THE PRIESTLEY HOUSE AND MUSEUM FROM THE SOUTHWEST

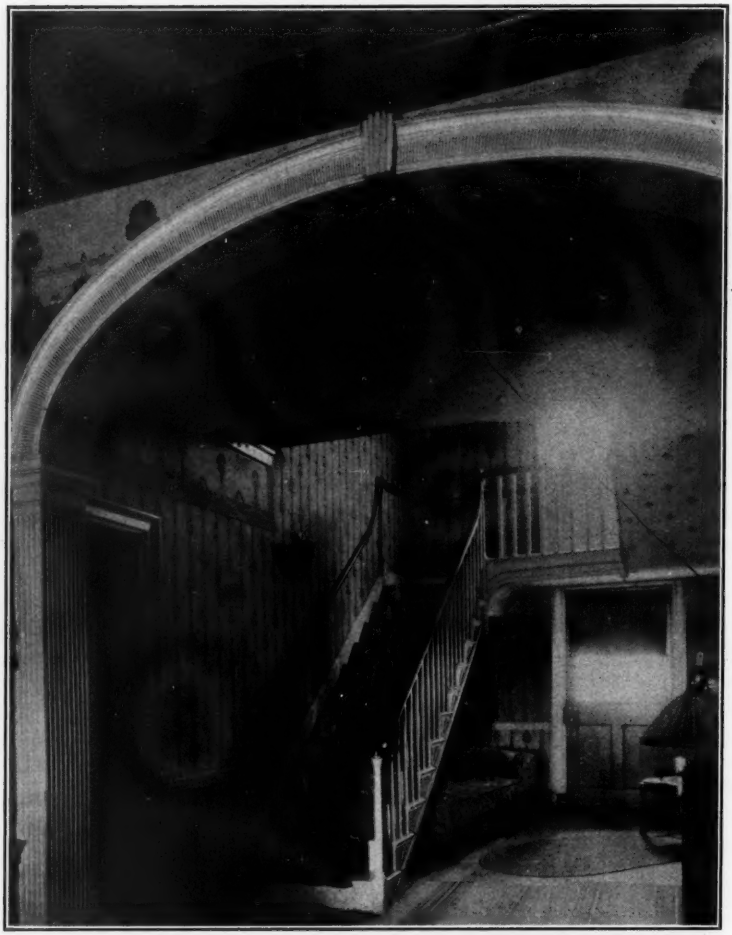
the foreigners had been ejected can appreciate the change that has taken place; but we can all now see its attractive present and its very promising future.

Dr. Pond's plan included a fireproof room constructed in some part of the house, preferably the laboratory, into which could be gathered the many pieces of apparatus used by Dr. Priestley which are still in existence. These are now more or less scattered; but it was his hope and belief that if a safe and adequate room were provided for holding such precious mementos of the great Priestley, that their present owners would gladly assemble them for the common good. Because of fire-engineering difficulties it was found impossible to construct such a room. But in its place there has been provided near the house and adjoining the laboratory a small museum of the best modern fireproof construction. Concerning the Priestley apparatus which is now there, and that which is to come, Dr. Browne will presently tell us.

It seemed best to the chemical alumni of the Pennsylvania State College that a property so dear to the hearts of the chemists of the country should be held by a more widely representative organization. Hence, the George Gilbert Pond Memorial Association has been created and a charter from the Commonwealth of Pennsylvania is now issuing which will provide for a Board of Trustees in which will be vested the title to the Priestley property and the fund provided for its maintenance. This Board will be composed of appointees from the Pennsylvania State College, the American Chemical Society, the American Philosophical Society, and the Pennsylvania Historical Society. Because of his generous contribution to this maintenance fund we desire at this time to mention the name of the late Mr. Frederick E. Atteaux, chemical merchant and manufacturer of Boston, Mass.

It is our hope that the time may come when some honored scientist will wish to retire from active life, and come to live in this beautiful old home, and pursue his chemical research in the old Priestley laboratory. The house is full of interesting possibilities, and it requires no imagination to see the laboratory adequately equipped for modern scientific research. Then will Dr. Pond's dream have become a reality and the Priestley home be preserved for all posterity.

X-Ray Aid Making Modern Motor Cars. X-rays can play their part in the manufacture of an automobile, George L. Clark, of the department of chemical engineering of the Massachusetts Institute of Technology, told the Society of Automotive Engineers. The short, penetrating rays give the scientists clues to the ultimate structure of materials, aid the metallurgist in making new combinations of metals and understanding those already perfected, allow the engineer to detect defects in the fabrication of metals used in the cars, and give information aiding the utilization of rubber, asbestos, fibers, lubricants, paints, and other materials.—*Science Service*



MAIN HALLWAY OF PRIESTLEY HOUSE, LOOKING NORTH TOWARD STREET ENTRANCE, AND SHOWING COLONIAL STAIRCASE

PRIESTLEY'S LIFE IN NORTHUMBERLAND AND DISCUSSION OF THE PRIESTLEY RELICS ON EXHIBITION IN THE MUSEUM*

C. A. BROWNE, CHIEF, BUREAU OF CHEMISTRY, WASHINGTON, D. C.

Seven years ago, on the fourteenth of November, while I was working in my laboratory on the East River water front of New York City, I was delighted to receive a visit from my old friend Professor George Gilbert Pond, at that time the Acting President of the Pennsylvania State College. Little did I realize that this was to be the last meeting in the twenty-eight years of our acquaintance. In the course of our conversation on that pleasant autumn day Professor Pond remarked to me very casually that he had recently purchased at an auction sale the home of Joseph Priestley. This piece of intelligence not only thrilled but greatly interested me. In former days, while traveling to or from State College, I frequently stopped at Northumberland to visit the old residence where Priestley worked and died. It had always appealed to me as a precious inheritance which deserved to be set apart and preserved as a permanent memorial. Professor Pond's intention to insure the preservation of Joseph Priestley's home against possible misuse or destruction was, therefore, hailed by me with delight. The credit of insuring the future preservation of Joseph Priestley's last home as a Mecca for future generations of American chemists belongs entirely to him and the loyal alumni of Pennsylvania State College are to be congratulated upon their share in making possible the realization of this project.

After an interval of over one hundred and twenty-two years since the death of Joseph Priestley we have gathered here today to participate in the dedication of his home as a permanent memorial, and the question might well be asked, "What is there about the life and last residence of this simple unassuming clergyman which entitles them to such distinction?" There are many reasons for this and they have been so well summarized by that eminent English critic, historian, and jurist, Frederic Harrison, that I will quote his words:

> If we choose one man as a type of the intellectual energy of the eighteenth century we could hardly find a better than Joseph Priestley, though his was not the greatest mind of the century. His versatility, eagerness, activity and humanity; the immense range of his curiosity in all things, physical, moral or social; his place in science, in theology, in philosophy and in politics; his peculiar relation to the Revolution, and the pathetic story of his unmerited sufferings, may make him the hero of the eighteenth century.

If anyone should doubt the accuracy of Mr. Harrison's estimate let him go to some large library and note the stupendous number of biblio-

* Read at the meeting on the lawn of Joseph Priestley's house, Northumberland, Pa., September 5, 1926, as a part of the exercises connected with the pilgrimage made by chemists during the golden jubilee of the American Chemical Society.

graphic references to books, tracts, and articles about Priestley. If curiosity should prompt the inquirer to investigate further he would find that Priestley had made his influence felt not only in the fields of theology and science, but also in those of politics, industry, philanthropy, sociology, philosophy, history, and education. The hold which he acquired upon the thoughts of men during his residence in England and America was tremendous and his influence is destined to remain as long as the English language is spoken. Priestley is one of those common possessions which, belonging to England and America alike, tend toward promoting a unity of thought and understanding. Rumford, the founder of the Royal Institution and of the Rumford Professorship at Harvard, is another such common possession. Unjust suspicions and threats of violence obliged Rumford to find protection in England; religious and political persecutions forced Priestley to become an exile to America. Although forcibly accomplished, it was our first international exchange of scientists.

It was on June 4, 1794, that Doctor and Mrs. Priestley, after a long two months' voyage from England, arrived in America. Following a series of hearty receptions in New York and Philadelphia they proceeded to the home of their son in Northumberland, which was then a frontier settlement almost in the heart of a wilderness. The first thought of the distinguished exile was the erection of a house and laboratory where he could continue the work which had been so harshly interrupted by the destruction of his home in England during the riots of Birmingham. Doctor Walker has told you the story of the erection of the present house and it now devolves upon me to describe briefly some of the accomplishments of Priestley during his residence in Northumberland from the time of his arrival here until his death in February, 1804. Never were his intellectual vigor, industry, and astonishing versatility better displayed than during these last years.

In evaluating the scientific and literary accomplishments of Priestley during this closing period of his life we must take into account the great difficulties and limitations under which he worked. Northumberland, at the time of his arrival here, was almost in the heart of a wilderness. A stage made the journey to Philadelphia only once in six weeks and the difficulties of communication, whether by land or water, were almost insuperable at certain seasons of the year. Those of us who made the journey today from Philadelphia to Northumberland can only faintly realize the troubles which Priestley encountered in transporting his library and laboratory equipment to this junction of the branches of the Susquehanna.

Literary and scientific friends, who were such an inspiration to Priestley in England, were wholly absent here and this lack of stimulating companionship was a serious loss. But, deprived as he was of these and

other cultural advantages, he took a most complacent view of his altered situation and with fine philosophy speedily adapted himself to life in the "back woods." By establishing one of the best equipped libraries and laboratories of his time in Northumberland, Joseph Priestley advanced the intellectual frontier of the United States many miles to the westward.

The first piece of scientific work which Priestley performed in Northumberland was one that might naturally be expected of so eminent a representative of the pneumatic school of chemistry. On May 22, 1795, he wrote to his friend Dr. Rush, "the day after I received your favour I, having just then got my apparatus ready, made trial of the air of Northumberland by the test of nitrous air, but found it not sensibly different from that of England." This is one of the earliest recorded attempts to analyze the air of the Western Hemisphere.

The chemical discovery of greatest importance which Joseph Priestley made in his Northumberland laboratory was that of carbon monoxide, which he obtained in 1799 by passing steam over heated charcoal and also by heating "finery cinder and charcoal." It was the last of the long series of gases that Priestley discovered. Oxygen, ammonia, hydrogen chloride, hydrogen sulfide, nitric oxide, nitrous oxide, sulfur dioxide, and carbon monoxide—to name them all—and it is a list which places Priestley's name for all time among the front rank of chemists. One has only to think of what these gases mean to modern industry and civilization. It was with reference to Priestley's discovery of carbon monoxide in Northumberland that Sir Thomas E. Thorpe, the eminent English chemist and biographer of Priestley, once wrote so charmingly:

> If, too, as you draw up to the fire betwixt the gloaming and the mirk of these dull, cold, November days, and note the little blue flame playing around the red-hot coals, think kindly of Priestley, for he first told us of the nature of that flame when in the exile to which our forefathers drove him.

Interesting observations upon spontaneous combustion, the diffusion of gases, the liberation of air from water, the solution of glass by caustic alkalies, and other chemical phenomena too numerous to mention were also made by Priestley in the seclusion of his Northumberland laboratory. These miscellaneous chemical activities were regarded, however, by the good Doctor as mere chips of his Northumberland workshop when compared with the great dominating purpose, so frequently expressed in his correspondence, "of overturning the French new theory of chemistry" proposed by Lavoisier. It was for the confirmation and final vindication of his favorite doctrine of phlogiston that he chiefly labored and so "in 1800," to quote from his biographer, Doctor Thorpe, "he put together his last scientific work, and the one which he regarded as the crown of all his efforts, viz., his 'Doctrine of Phlogiston Established.'" This final chal-

lenge of the last champion of phlogiston against the swelling army of the new chemical school is a most interesting work and one greatly prized by the collectors of rare scientific books. On turning its pages we are transported back over two centuries to the time when Stahl first explained chemical phenomena by proposing the existence of a hypothetical fire-substance which he termed "phlogiston." His doctrine, although incorrect, served a most useful purpose, for out of the battles which were fought for its overthrow and defence was secured the experimental evidence that became the foundation of modern chemistry. It is worth knowing that the last shot in this historic conflict was fired by Doctor Priestley from the stronghold of his Northumberland laboratory.

Priestley, in one of his intimate letters, expresses a sincere belief in the final triumph of his doctrine of phlogiston.

> The annual expense of my laboratory (he writes) will hardly exceed 50 pounds, and I think I may have done more in proportion to my expenses than any other man. What I have done here, and with little expense, will in time be thought very considerable; but on account of the almost universal reception of the new theory, what I do is not, at present, attended to; but Mr. Watt and Mr. Kier, as good chemists as any in Europe, approve of my tract on *Phlogiston*, and truth will in time prevail over any error.

The defenders of phlogiston, as we review their writings, seem to have viewed everything reversed. To them the ponderable was imponderable, combination was decomposition, elementary substances were compounds, and compounds were elementary. Conclusions exactly opposite to those which they deduced can be drawn from all their arguments, and so Priestley's own experiments became the best weapons of his opponents. But such use of his discoveries aroused no anger on the good Doctor's part. He paid smiling attention to the arguments of the other side and simply said: "It is not my opinions on which I lay stress. Let the new facts, from which I deduce them, be considered my discoveries and let other persons draw better inferences if they can." This simple, truth-loving attitude made him the perfect expression of amiability, and so it happened that those who differed most from his opinions were often his strongest friends.

Priestley lived altogether only a little over six years in the house which he built in Northumberland, but in this small period he made a record of accomplishment such as few men can show in an entire lifetime. There were many other activities besides those of chemistry which engaged his attention. It was in this house that he completed his "General History of the Christian Church," his "Notes on the Scriptures," his "Comparison of the Institutions of Moses with Those of the Hindoos," his much discussed "Letters to the Inhabitants of Northumberland," and his little pamphlet "Socrates and Jesus Compared." It was here that he conducted a most interesting and intimate correspondence with old friends

in England and with Thomas Jefferson, Benjamin Rush, Samuel L. Mitchill, and other prominent men in America. It was here that he lectured to a class of young students upon theology and philosophy, that he considered methods of education and evolved plans, unfortunately never realized, for founding a college in Northumberland. It was here that he devoted several hours of each day to readings in Hebrew, Greek, Latin, and modern languages. It was from this house that he made his occasional visits to Philadelphia where he attended the meetings of the American Philosophical Society and enjoyed the social life of the metropo-

PRIESTLEY HOUSE FROM THE SOUTHEAST
(Showing Priestley's Laboratory in the "L.")

lis. And, finally, it was to this house that he returned broken in health, yet still filled with an unquenchable desire to labor and serve. His career was an active one, rich in contacts, friendships, and accomplishments, so that he could truly say to his good friend Doctor Rush: "I have abundant reason to be satisfied and shall retire from life *conviva satur*."

Only a few days before the end he struggled to his laboratory and lit his fire, eager to make some new experiment, but the effort was too much for his feeble strength and he was obliged to return for rest to his study. His final hours were spent in dictating corrections in his proofs. When

these were read to him he replied, "That is right; I have now done," and with these last words one of the world's greatest truth-seekers passed quietly away.

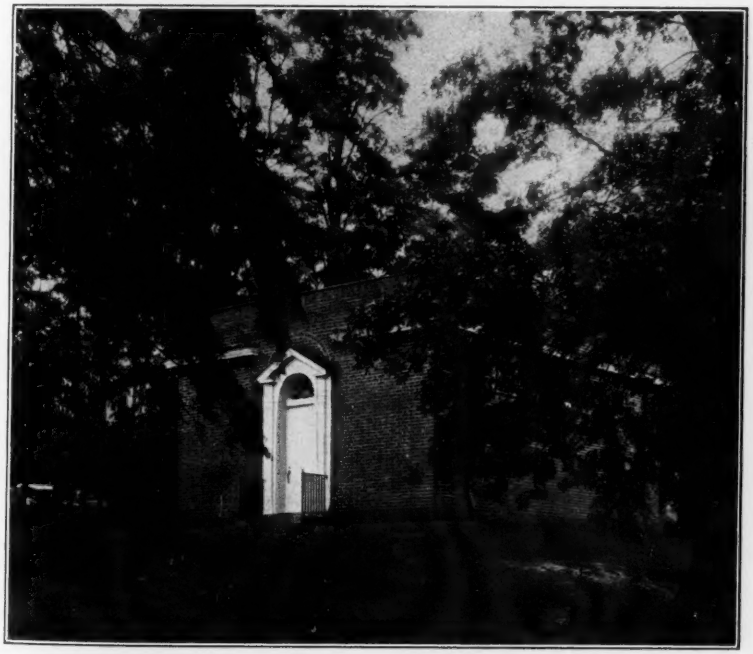
It was only last Tuesday that I visited in Virginia the residence and last resting place of Thomas Jefferson, the author of the Declaration of Independence of which we are now celebrating the one hundred and fiftieth anniversary. As I looked down from Jefferson's mountain home upon the University which he founded and over the beautiful valley of the Blue Ridge, I thought of the close friendship which existed between our third President and Joseph Priestley. It was in this beautiful valley that Jefferson invited Priestley to make his home and it was in the University which he was proposing to establish that he thought of offering Priestley a professorship. The aged exile of Northumberland was, however, too far advanced in life to consider such an undertaking. "Were I a few years younger," he wrote to Jefferson, "and more movable, I should make interest for some appointment in your institution myself; but age and inactivity are fast approaching, and I am so fixed here that a remove is absolutely impossible unless you were possessed of *Aladdin's lamp*, and could transport my house, library and laboratory, into Virginia without trouble or expense."

But while Priestley was unable to move to Virginia he assisted Jefferson in no small degree by the suggestions which he made regarding methods of instruction. In reading the "Hints Concerning Public Education" which Priestley prepared for Jefferson, we are not only surprised at the extreme modernism of his educational opinions but we are led to wonder how many of Priestley's ideas were incorporated by Jefferson in the project of his new university. Jefferson and Priestley resembled each other so greatly in intellectual tastes and in the liberal views which they held with regard to politics, philosophy, and religion that their friendship was a natural consequence of the strong admiration which each of these men conceived for the other.

* * * *

Through the enterprise and liberality of the members of the G. G. Pond Memorial Association the preservation of the house and laboratory which Joseph Priestley erected has not only been assured, but there has been constructed here a beautiful fireproof museum for containing certain relics of the famous discoverer of oxygen. The success of this project has been made certain by the willingness of some of the descendants of Doctor Priestley and of various others who possessed objects that are associated with his memory to deposit their treasures in this museum for the benefit and pleasure of future generations. The extensive collection of memorabilia which are exhibited here today, consisting of apparatus, letters, manuscripts, books, book plates, prints, portraits, personal

effects, and other objects—hastily assembled and too numerous to describe individually—must not be regarded, however, as the final aggregate of what this museum may be expected to contain. I know from my own limited experience as a collector the abundance of letters, documents, pamphlets, books, prints, and other material pertaining to Priestley which can still be acquired in England, America, and other parts of the world. The directors of this museum and the many admirers of Priestley in the United States will no doubt be constantly in search of new acquisitions to enhance the value of the present collection.



JOSEPH PRIESTLEY MUSEUM FROM THE SOUTHWEST

From the memorabilia which are deposited here the visitor will be able to form a vivid conception of the personality and versatile genius of Joseph Priestley. He will be able to reconstruct the numerous contacts and activities of his busy life just as the visitor at Mt. Vernon is enabled, from its buildings, gardens, and collections, to form a conception of the interests and pursuits of Washington. No object, however small or trivial, should be ignored, for if it has some bearing upon the life or work or diversions of Priestley it will speak eloquently of the man. Here should

be gathered as much as possible of his original apparatus, of his original furniture and of the original books, which, to the number of four thousand, filled the shelves of his library. Here should be deposited as many as possible of the documents, papers, and letters that were written by his hand. The student of Priestley's life should find here every edition of his numerous books; all the various published references to him or to his works; all the biographies and accounts of his life which have been printed; and originals or copies of all the prints, cartoons, portraits, and medallions that bear his likeness. The late Henry Carrington Bolton, the well-known historian and bibliographer of chemistry, described no less than eighty-four different likenesses of Priestley—painted, engraved, lithographed, stamped, moulded, cast, and carved—and there are many others unknown to Doctor Bolton, which might be added to his list. There are shown here at Northumberland today many different portraits of Priestley, which I hope all of you will examine after the close of the present meeting.

Among other museum objects to which I invite your attention are bell jars, tubes, glassware, and other small pieces of Priestley's chemical apparatus; a surveying instrument; his microscope with sections and other accessories; several telescopes with their attachments; and a magic lantern with various slides which Priestley is said to have used for entertaining his children and grand-children. Priestley was very fond of optical experiments and there is a well-founded tradition that the original west shutter of the south-west window on the second floor of this dwelling contained in the upper part a small hole, bored there by Priestley for the purpose of admitting into the darkened room a narrow beam of sunlight which he resolved with a prism into the various colors of the spectrum. This shutter was unfortunately taken away years ago by a curio hunter and no trace of it remains.

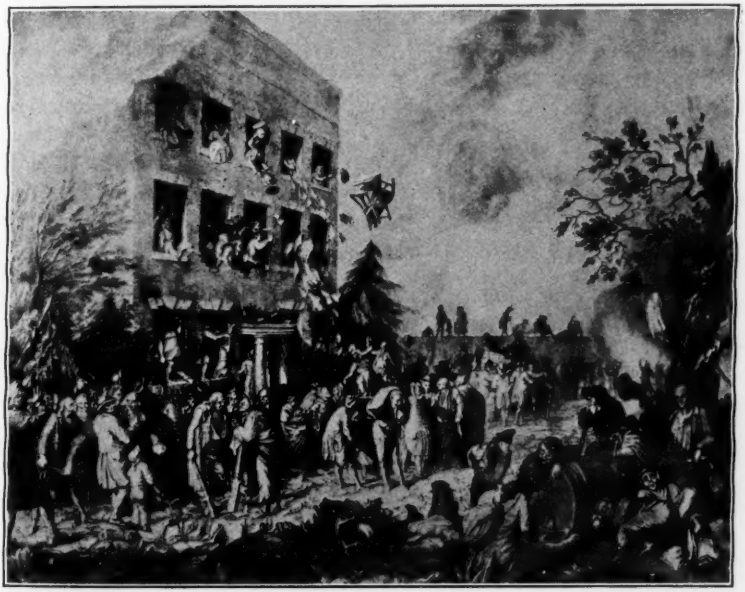
Among some of the more personal objects which are exhibited here today are Dr. Priestley's snuff box, glasses, and chess board. Upon the back of the latter he once wrote his name which, although faintly legible, can still be read.

Among the numerous manuscripts, documents, and other papers in Priestley's handwriting deposited in this museum there is an autograph letter which I would particularly ask you to examine. It was written by Priestley at Reading on April 17, 1801, as he was traveling home with his daughter from Philadelphia, where he had just suffered from a serious illness. In conveying to his friend John Vaughan the impressions of this journey he writes:

> Along the whole road I am struck with the marks of an astonishing degree of improvement since I came this way four years ago. I do not think that any part of England is better cultivated, and at present the wheat is in a very promising state. I wish

we may hear of that of England promising as well. Three years of such a scarcity is more than any country could bear and you will believe me when I say that, if it was in my power, I would guard it not only from famine, but from every other calamity.

Glance at this letter, for its faded pages will bring to you most vividly the deep love which Priestley always bore to England in the days of his exile, notwithstanding the unmerited hostility and sufferings which he endured at the hands of his former countrymen.



THE DESTRUCTION OF PRIESTLEY'S ENGLISH HOME
An engraving after a sketch made on the spot. Photographic reproduction loaned by Dr. Elwood Hendrick.

While the mementos of Priestley's Northumberland career form very properly the most conspicuous part of the objects which are deposited here, the souvenirs of his previous life in England should not be overlooked. Objects relating to the Birmingham riots, which were the cause of his coming to America, are also exhibited here today. Among them is a copy of the *Gentleman's Magazine* for July, 1791, which contains a contemporaneous account of this destructive uprising, a copy of Priestley's letter to the Inhabitants of the Town of Birmingham upon the loss of his house, apparatus, and library, and a copy of a very unfriendly anonymous reply which this letter evoked. Here also is one of the mutilated chemical

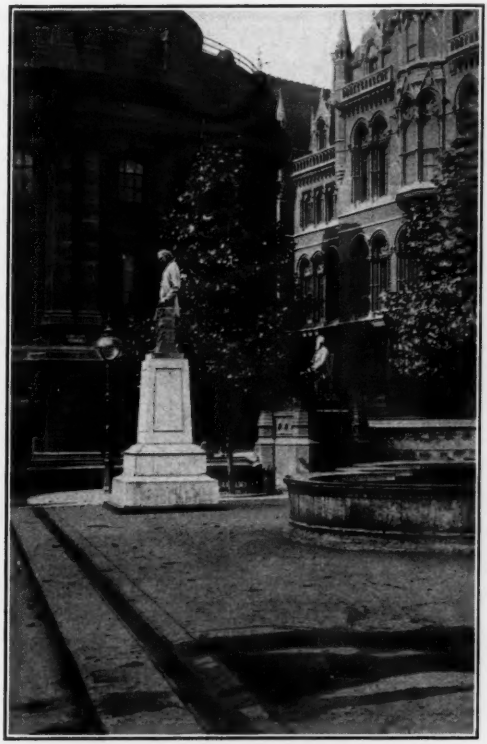
books, with Priestley's famous book plate, which survived the depredations of the mob that burned his house and pillaged his library.

Objects connected with Priestley's acquaintance in England with Benjamin Franklin also find here a very appropriate resting place. The warmest friendship existed between Franklin and Priestley, who resembled each other so closely in their love for science, in their spirit of liberalism, in their political opinions, and in their versatility. "There can be no question," wrote Doctor Thorpe in his "Life of Priestley," "that the friendship (of Franklin) reacted powerfully on Priestley's work as a political thinker and as a natural philosopher. Indeed, it may be truthfully said that Franklin made Priestley into a man of science." As an evidence of this influence there is shown among the objects exhibited here today a copy of Priestley's first scientific book, "The History and Present State of Electricity," which was written with the encouragement of Franklin. As another example of this friendly support there is shown among the exhibits a copy of Priestley's "History of Discoveries Relating to Vision, Light and Colours," in which Franklin has set down his name as a subscriber to the generous extent of twenty copies. Among other evidences of Franklin's friendship to Priestley there are exhibited in the museum a Wedgewood pottery medallion of Franklin and his terra cotta bust by Nini which were once presented to Priestley by the great patriot and philosopher himself. The lives of Franklin, Jefferson, and Priestley are so interwoven by friendly influences and personal contacts that this memorial in Northumberland should be a Mecca not only for chemists but for every loyal American.

SITE OF THE PRIESTLEY HOUSE, BIRMINGHAM ENGLAND

This is now a part of Birmingham; in Priestley's day it was out in the country. Photograph, 1925, by Dr. J. Newton Friend.

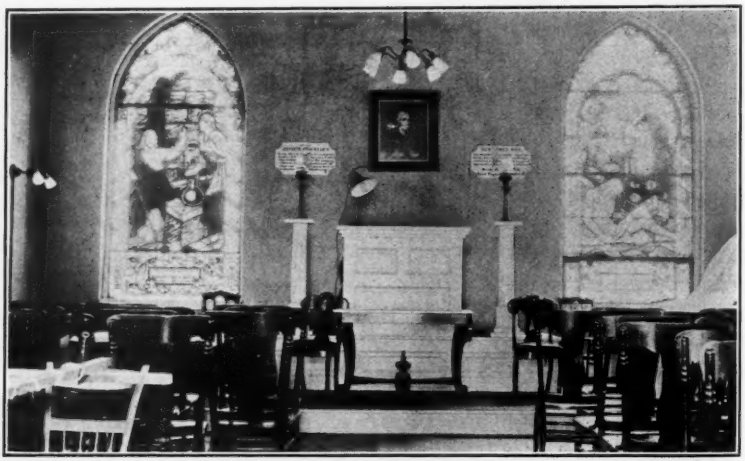
As might be expected with a person of Priestley's prominence, there are other exhibits of his relics besides the one which is now established in Northumberland. At Burlington House, London, there is a valuable collection of portraits, letters, engravings, and other memorabilia, which was bequeathed to the Royal Society by one of its deceased members, Mr. James Yates. Another collection, assembled by Samuel Timmins, is preserved in the Reference Library of Birmingham, England, where Priestley lived from 1780 until 1791. There are also deposited at Dickinson College, Pennsylvania, and at the Smithsonian Institution in Washington various pieces of chemical, electrical, and optical apparatus with which Priestley worked in his Northumberland home. President J. H. Morgan and Professor Eddy of Dickinson College have very kindly brought over from Carlisle for your inspection today Priestley's large compound burning glass, his airgun and compressor, two large mounted telescopes, and various pieces of glass apparatus. The various objects exhibited in the museum will enable you to form an idea of the extensive range of Priestley's scientific interests. It is planned eventually to install in the wing of this residence (nearest to the museum) a replica of the original laboratory where Priestley worked—a laboratory which in its day was the most extensive and complete in the western world.



THE PRIESTLEY STATUE, BIRMINGHAM, ENGLAND
The curving wall of Birmingham Public Library appears in the background. Photograph by Dr. J. Newton Friend.

In the Timmins collection of Priestley relics in Birmingham there are also preserved mementos of the celebration in 1874, when a statue was erected to Priestley in commemoration of the hundredth anniversary of the discovery of oxygen. A small replica of this statue, presented to the museum by Professor Edgar F. Smith of the University of Pennsylvania, can be seen among the objects exhibited in the Museum.

Simultaneous with the celebration at Priestley's English home there was held a Centennial Anniversary at his American home and an exchange of cablegrams between Birmingham and Northumberland was a pleasant feature of that double celebration. Just as mementos of the English anniversary are preserved in Birmingham, souvenirs of the American meeting, consisting of photographs of the attending chemists and other



INTERIOR OF JOSEPH PRIESTLEY MEMORIAL CHURCH, NORTHUMBERLAND, PA.
Photograph, 1921, by Dr. Louise McDanell Browne.

memorabilia, are deposited here in Northumberland. Following the establishment of this memorial and the constant enrichment of its collections, this spot will long continue to be a meeting place for future gatherings and the records of all such celebrations should be carefully preserved in this home of Joseph Priestley.

The services which Priestley accomplished for the advancement of science, for the improvement of humanity, and for the promotion of religious toleration were so far-reaching in their effects that the testimonials established in his honor are among the most precious heritages of our modern civilization. The memorial which is dedicated here in Northumberland today is unique among all others in being established in the very home which Priestley built and where he worked and died. From the

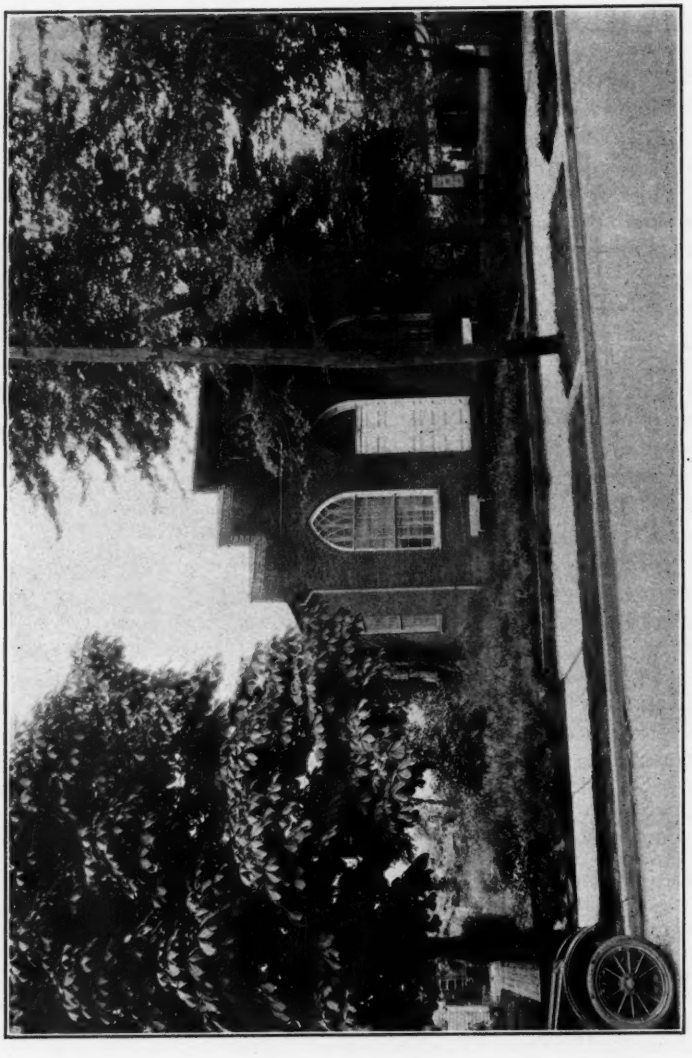
doorway of his house the visitor can enjoy the same distant outlook which caused the aged exile upon his arrival here to remark that nothing can be more delightful. It was on this spot that he cultivated the little garden which was so great a pleasure in his later years. Here also in full view of the river and hills which once delighted his eye is the very grave of Priestley himself.

It is almost exactly five years ago when making my last visit to this town that I called upon Miss Annie Priestley, a great-great-granddaughter of Joseph Priestley, and the last one of his name to live in Northumberland. She welcomed me most graciously and in the course of our conversation remarked that the conversion of this old homestead into a permanent memorial would be the fulfillment of a long-cherished desire. She showed me many souvenirs of Doctor Priestley and finally conducted me to the little chapel of the Unitarian Society, which Priestley founded in Northumberland, where certain matters awaited her attention. Her kindness, amiability, culture, benevolence, zeal for the truth, and leadership in work for human welfare are pleasant to recall and those who knew her are prompted to reflect that these were the same inherited traits which made her distinguished ancestor so greatly loved. It is a satisfaction to know that her wishes regarding the preservation of the old Priestley homestead have now been realized, although we regret that she herself was called away before the present dedication.

The purpose of this memorial is not to glorify the accomplishments of Priestley, but to perpetuate a knowledge of his life and character. His career is a refutation of the false idea, so commonly expressed, that the pursuit of science is destructive of religion. Love for science and devotion to religion were so combined in him that his scientific writings are permeated with a spirit of lofty reverence. I can close my remarks in no better way than by quoting his words upon the moral benefits which are derived from the pursuit of science:

> The Philosopher (he says) ought to be something greater, and better than another man. The contemplation of the works of God should give a sublimity to his virtue, should expand his benevolence, extinguish everything mean, base and selfish in his nature, give a dignity to all his sentiments, and teach him to aspire to the moral perfections of the Great Author of all things. What great and exalted beings would philosophers be, would they but let the objects about which they are conversant have their proper moral effect upon their minds. A life spent in the contemplation of the productions of divine power, wisdom and goodness, would be a life of devotion. The more we see of the wonderful structure of the world, and of the laws of nature, the more clearly do we comprehend their admirable uses to make all the percipient creation happy; a sentiment which cannot but fill the heart with unbounded love, gratitude and joy.

Joseph Priestley's own life was a shining example of the ideal which he has so eloquently described.



UNITARIAN CHURCH AT NORTHUMBERLAND
Congregation founded by Priestley in 1796. This building erected in 1834.

ONE OF PRIESTLEY'S FIRST LETTERS WRITTEN FROM NORTHUMBERLAND, PA.*

LYMAN C. NEWELL, BOSTON UNIVERSITY, BOSTON, MASSACHUSETTS

Priestley sailed to America on April 8, 1794, and landed in New York on June 4th. After a fortnight's visit he went to Philadelphia, remained there until the middle of July when he started for Northumberland where his son, Joseph Priestley, Jr., had preceded him and established a home on a piece of land which had once belonged to James Woodhouse and had been conveyed by Benjamin Rush on February 18, 1794, to the younger Priestley. Here the son received his father. Priestley was contented in Northumberland from the beginning of his life there, and well he might be after the turmoil of the preceding years.

Priestley's immediate tasks upon his arrival in Northumberland were two—clearing land and conducting correspondence. The land was needed for a home for himself, his wife, and the unmarried members of his family, while the letters were necessary to retain the loyalty of his old friends in England and to maintain the friendship of his new ones in America. Letters written by Priestley during these early days in Northumberland illustrate the two absorbing tasks.

One of these letters, which came into my possession a few years ago, was written to Mr. George Humphries at Mr. John Vaughan's, Philadelphia. It is dated October 15, 1794, and reads as follows:

"Dear Sir:

I received your letter of 6 October & have paid Mr. Jenkins the 20 dollars you inclosed. I wrote to you last week that I had agreed to take the house. I am moving into it, & wait the receipt of your agreement with Jenkins to enter into a fresh one with him. Davy has been with Scott about the island & offered him £3000 & it is not certain he will sell it for that. Every one asks so much for their property that Davy is discouraged.

Jenkins says the lot on which the distillery is placed is not included in the purchase, & he will not sell it tho' only 40 feet in front under £50 & the intermediate lot of only 40 feet cannot be had under 100 dollars.

Bonum, Montgomery & Mackay are going to be taken up & taken to headquarters. Dr. Young says Bonum will be hanged, however I think that is all a farce as they have only to charge him with having

* Read before the joint session of the Division of Chemical Education and Section of History of Chemistry at the Seventy-Second Meeting of the American Chemical Society, Philadelphia, Pa., September 9, 1926.

made use of some foolish expressions which at most would only amount to sedition.

I remain with best respects to John & Henry,

Yours,

J. Priestley."

The significant feature of this letter is the portion devoted to land. Priestley was English at heart, though an exile from his native country, and like most Englishmen he loved the open country and craved ownership of broad lands. Scarcely had he set foot in Northumberland when he began to negotiate for land. The Davy referred to in this letter was a resident of Sunbury who kept a diary of his experiences. An entry made toward the end of 1794 says, "He (Priestley) has bought a lot of eleven acres (exclusively of that which he is building on), which commands a delightful view of all the rivers, and both towns, *i. e.*, Sunbury and Northumberland and the country. It cost him £100 currency."

About the same time his favorite son, Harry, bought 300 acres of land and began to clear it. Not only was Priestley interested in this work, but he actually helped in the labor of removing the timber. Letters, documents, and notes show that Priestley loved his home and his lands in Northumberland, and in this letter written so soon after his arrival there is a bit of historical evidence of this fact.

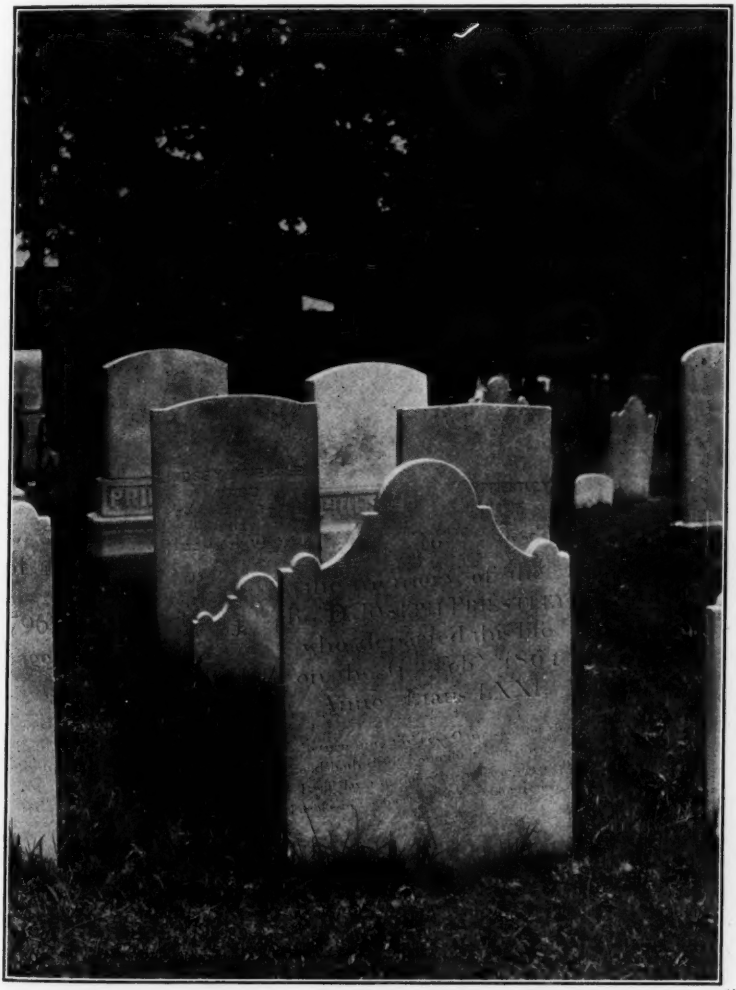
Would Have Research on Disease-Carrying Insects. A research institution that has for its object the detailed study of all the known insect carriers of disease is a new project in science. A proposal for such a beneficent foundation has been made by Dr. L. O. Howard, chief of the U. S. Bureau of Entomology, in the annual report of the Smithsonian Institution.

Not only the insects of bad reputations of long standing, like the anopheles mosquito associated with malaria, but the close relatives of all the disease-bearing species should be studied in a well-equipped service "by competent men untrammeled in their work and assisted to the limit of their necessities in a financial way," declares Dr. Howard.

Organic chemistry as an aid to the entomologist in dealing with the insect pest problem was stressed by the well-known scientist in his report. Knowledge of the chemistry of the physiological changes that insects undergo is essential, he stated. Study of the chemistry of the plants on which they feed would help to give a clearer understanding of what there is about certain plants that attracts certain insects. Such problems would have a very important bearing economically on many crop pests.

Annihilation of injurious insects by poison gas is another phase of chemistry along the lines of which Dr. Howard believes valuable progress may be made in the future.

"We must look to the chemist," he declared, "for the development of the most perfect insecticide, which must be a cheap compound that will at once stimulate plant life and deter or destroy insects."—*Science Service*



GRAVESTONE OF DR. JOSEPH PRIESTLEY IN CEMETERY AT NORTHUMBERLAND

"To the memory of the Rev.d D. Joseph Priestley who departed this life on the 6th Feby., 1804, Anno Etatis LXXI.
"Return unto thy rest O my soul for the Lord hath dealt bountifully with thee.
" I will lay me down in peace & sleep till I awake in the morning of the resurrection."

PRIESTLEY'S LAST DEFENSE OF PHLOGISTON*

TENNEY L. DAVIS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

Priestley's last defense of phlogiston appeared in 1804 in the second edition, actually dated 1803, of the pamphlet entitled "The Doctrine of Phlogiston Established, and That of the Composition of Water Refuted." This work appeared after the death of its author, for Priestley died February 6, 1804, and the pamphlet contains a letter by Joseph Priestley, Jr., which is dated February 29th of the same year. It is especially interesting because it shows Priestley's final opinion about phlogiston, and it shows that his opinion was not altered in the least by seven years of controversy with his antiphlogistian opponents. It further makes it clear that Priestley's principal interest was in theological more than in chemical matters, and so suggests an explanation of the fact that phlogiston, to the last, seemed to him to be thoroughly defensible.

Priestley's chemical writings, after his removal to America, consist of papers which he published in this country in the Medical Repository of New York and in the Proceedings of the American Philosophical Society of Philadelphia, of papers which he sent to England for publication in Nicholson's Journal of Natural Philosophy, Chemistry, and the Arts, and of several pamphlets which are devoted to the defense of the phlogiston doctrine.[1] These little-known pamphlets are written in the splendid English of which Priestley was master, and contain much that is quotable. Among various libraries I have never seen more than one copy of any one of them. They are the documents of the wane of phlogiston. Their rarity makes it worthwhile to enumerate them.

CONSIDERATIONS ON THE DOCTRINE OF PHLOGISTON, AND *The Decomposition of Water*. By JOSEPH PRIESTLEY, *LL.D. F.R.S.&c.&c.* PHILADELPHIA; Printed By Thomas Dobson, At The Stone-House, No. 41, South Second-Street. 1796. 39 pages. (Copy in the Boston Public Library.)

OBSERVATIONS ON THE DOCTRINE OF PHLOGISTON, AND *The Decomposition of Water*. Part II. By JOSEPH PRIESTLEY, *LL.D.F.R.S.&c.&c.* PHILADELPHIA; Printed By Thomas Dobson, At The Stone-House, No. 41, South Second-Street. 1797. 38 pages. (Copy in the Harvard College Library.)

THE DOCTRINE OF PHLOGISTON *ESTABLISHED*, AND

* Read before the joint session of the Division of Chemical Education and Section of History of Chemistry at the Seventy-Second Meeting of the American Chemical Society, Philadelphia, Pa., September 9, 1926.

[1] For a fuller account of these pamphlets, see the chapter by the present writer in the Festschrift in honor of Professor Edmund O. von Lippmann, published by Julius Springer, Berlin, 1926.

THAT OF THE COMPOSITION OF WATER REFUTED. By JOSEPH PRIESTLEY, *L.L.D.F.R.S.&c.&c.* NORTHUMBERLAND: PRINTED For The AUTHOR By A. KENNEDY. MDCCC. xv + 92 pages. (Copy in the Library of Congress.)

THE DOCTRINE OF PHLOGISTON *ESTABLISHED*, AND THAT OF THE COMPOSITION OF WATER *REFUTED*. The Second Edition With Additions. By JOSEPH PRIESTLEY, L.L.D.F.R.S.&c. NORTHUMBERLAND: *PRINTED FOR P. BYRNE, No. 72, Chestnut Street, Philadelphia*, BY ANDREW KENNEDY, Franklins Head, Queen Street. 1803. xxii + 120 pages. (Copy in the Library of the University of Pennsylvania.)[2]

The "Conclusion" of the last of these pamphlets, printed in 1804, contains several paragraphs which are taken verbatim or with little change from the "Considerations," etc., of 1796. The entire "Conclusion" is as follows:

Before the new theory of chemistry can be unexceptionably established, the following things must be done.

1. Whenever inflammable air, or *hydrogen*, is procured, evidence must be given of the production of a due proportion of *oxygen*, that is of 85 parts of this to 15 of the other; and this evidence must be something more than an addition of *weight*. It must be either actual *acidity*, or *dephlogisticated* air. Otherwise there is no proof of the inflammable air having come from the decomposition of the water. This, however, has not been done with respect to iron, or any other substance by means of which inflammable air is procured.

2. When water is procured by the burning of inflammable air in the dephlogisticated air, not only must the water be free from acidity, but there must have been no production of phlogisticated air in the process. For by the decomposition of this air the nitrous air may be procured.

On the whole, I cannot help saying, that it appears to me not a little extraordinary, that a theory so new, and of such importance, overturning every thing that was thought to be the best established in chemistry, should rest on so very narrow and precarious a foundation; the experiments adduced in support of it being not only ambiguous, or explicable on either hypothesis, but exceedingly few. I think I have recited them all, and that on which the greatest stress is laid, viz., that of the formation of water from the decomposition of the two kinds of air, has not been sufficiently repeated. Indeed, it requires so difficult and expensive an apparatus, and so many precautions in the use of it, that the frequent repetition of the experiment cannot be expected; and in these circumstances the practised experimenter cannot help suspecting the accuracy of the result, and consequently the certainty of the conclusion.[3]

But I check myself. It does not become one of a minority, and especially of so small a minority, to speak or write with confidence; and tho' I have endeavored to keep my eyes open, and to be as attentive as I could to every thing that has been done in this

[2] It is noteworthy that Priestley uses the letters F.R.S. after his name on the title pages of these pamphlets. The report that he resigned his membership in the Royal Society before he left England is, therefore, probably false.

[3] This paragraph, "The Doctrine, etc.," 2nd ed., p. 103, is taken verbatim from the "Considerations, etc.," pp. 37, 38.

business, I may have overlooked some circumstances which have impressed the minds of others, and their sagacity is at least equal to mine.[4]

Tho' the title of this work expresses perfect confidence in the principles for which I contend, I shall still be ready publicly to adopt those of my opponents, if it appears to me that they are able to support them. Nay, the more satisfied I am at present with the doctrine of phlogiston, the more honourable shall I think it to give it up upon conviction of its fallacy; following the noble example of Mr. Kirwan who has acquired more honour by this conduct than he could have done by the most brilliant discoveries that he could have made.

The phlogistic theory is not without its difficulties. The chief of them is that we are not able to ascertain the *weight* of phlogiston, or indeed that of the oxygenous principle. But neither do any of us pretend to have weighed *light*, nor the element of *heat*, tho' few persons doubt but that they are properly *substances*, capable by their addition, or abstraction, of making great changes in the properties of bodies, and of being transmitted from one substance to another.[5]

As to the *new nomenclature*, adapted to the new theory, no objection would be made to it, if it were formed, as is pretended, upon a knowledge of the real constitution of natural substances; but we cannot adopt one, the principles of which we conceive not to be sufficiently ascertained. For other objections to this nomenclature, I refer to the preface of Mr. Keir's excellent "Dictionary of Chemistry." However, whether we approve of this new language or not, it is now so generally adopted, that we are under the necessity of learning, tho' not of using, it."[6]

Priestley's state of mind with reference to the phlogiston controversy is clearly set forth in the preface to the first edition of "The Doctrine of Phlogiston Established, etc.," reprinted in the second edition, where he says—

The refutation of a fallacious hypothesis, especially one that is so fundamental as this, cannot but be of great importance to the future progress of science. It is like taking down a false light which misleads the mariner, and removing a great obstacle in the path of knowledge. The longer such an hypothesis has been received, and the more numerous and able are its advocates, the greater service is rendered to science by the refutation. And there is not perhaps any example of a philosophical hypothesis, since the revival of true science, more generally received, or maintained by persons of greater eminence, than this of the rejection of *phlogiston*. In this country I have not heard of a single advocate for phlogiston. In England there are very few, and none of them have written any thing on the subject. In France there are still fewer, and in Germany I hear of no names besides those of Crell, Westrumb, Gmelin, and Mayer....

But my philosophical friends must excuse me if, without neglecting natural science, I give a decided preference to theological studies, and if here, as in Europe, I give the greatest part of my time to *them*. They are unquestionably of unspeakably more importance to men, as being designed for immortality....No discovery in philosophy bears

[4] This paragraph, "The Doctrine, etc.," 2nd ed., pp. 103, 104, is taken verbatim from the "Considerations, etc.," p. 38.

[5] Except for the substitution of "few persons" for "we do not," this paragraph, "The Doctrine, etc.," 2nd ed., p. 104, is taken verbatim from the "Considerations, etc.," pp. 38, 39.

[6] This paragraph, "The Doctrine, etc.," 2nd ed., pp. 104, 105, is taken verbatim from the "Considerations, etc.," pp. 36, 37.

any proportion in real value to that of *bringing life and immortality to light*, which is completely effected in the Gospel, and no where else....

Now follow three pages of discussion of the importance of religious reflection and of revealed religion—

Call this, if you please, the talkativeness of age; but believe it to proceed from a zeal in the best of causes, and sincere good will to yourselves. For I find that I have insensibly got into a direct address in the form of a *dedication*, rather than that of a *Preface*. With this, however, I conclude. Farewell, and may we meet where our present doubts will be removed, and where we shall make more rapid advances in knowledge, without that envy and jealousy, from which philosophers are no more exempt than other men, and which, tho' it has an excellent effect in making men cautious, and even ardent in their pursuits, from a view to the reputation they hope to acquire by their discoveries, too often makes their pursuits the source of more pain than pleasure to them. Hereafter, we shall, I doubt not, be even more actively employed, and more happy in consequence of it, from better motives.[7]

In the dedication of the second edition of "The Doctrine of Phlogiston Established, etc.," addressed to Samuel Galton, Esq., a member of the Lunar Society of Birmingham, and dated Northumberland, October 20, 1803, Priestley says—

At my time of life, however, I could not expect to enjoy any society in this world much longer. Others, also, of our members, must now be looking forward, as I do, to a state of greater security and permanency than the present....

There only can I have any certain prospect of meeting with any of you. But the confident expectation that I have of meeting my philosophical and christian friends again, is a source of consolation and pleasing reflection in my present state of *exile* from them that is invaluable....

Tho' compared to this, the most important of all subjects, I feel but little interest in the question which, in this treatise, I bring once more before the Public.[8]

The closing sentences of the "Preface" of Priestley's last pamphlet proved to be prophetic.

I am truly thankful to the sovereign disposer of all things, and to those friends of science who have defrayed the expenses of my laboratory, that I have been able to do so much; and I hope my liberal benefactors will not repent their generosity. Indeed, the greater part of them are gone before me, to a state in which I shall hope soon to join them, where I can again express my gratitude, and when we may again unite our respective abilities in the same pleasing pursuits; seeing more of the wisdom and goodness of the great creator, and having our admiration and devotion excited to a greater height than ever.[9]

Priestley had addressed the "Considerations, etc.," of 1796, "To Messrs. Berthollet, De la Place, Monge, Morveau, Fourcroy, and Hassenfratz, The Surviving Answerers of Mr. Kirwan....And I request the favour of an answer to my objections." The French chemist, Adet, who was in the

[7] "The Doctrine of Phlogiston, etc.," 2nd ed., pp. vii, viii, ix, xi, xii.
[8] "The Doctrine of Phlogiston, etc.," 2nd ed., p. iv.
[9] "The Doctrine of Phlogiston, etc.," 2nd ed., p. xx.

United States as ambassador from France and had received Priestley's pamphlet quickly, translated it into French and replied at once with reasoning that was beautifully clear and entirely adequate.[10] Berthollet and Fourcroy replied later, in the 26th volume of the *Annales de Chymie*, in an article in which Priestley was considered as supporting a system *un peu chancelante*. But this reply did not satisfy Priestley. Indeed at every point in the controversy he seemed perfectly confident that the doctrine of phlogiston was thoroughly established and that the antiphlogistic chemistry was entirely refuted.

The second edition of "The Doctrine of Phlogiston Established, etc.," reprints from the "Considerations, etc.," Priestley's earlier letter to the French chemists, dated June 15, 1796, and contains a second letter to them, which ends wittily as follows—

> As a friend of the weak, I have endeavoured to give it [the doctrine of indeed phlogiston] a little assistance; and as there is no giving strength to one of the opposite systems without taking it from the other, I presume that yours is now in the same situation, calling to you for all the support that you can give to it.
>
> On the opening of this controversy I told Mr. Adet that I should have greater pride in acknowledging myself convinced, if I saw reason to be, than in victory, and should surrender my arms with pleasure. I was sincere in that declaration; and certainly the conquest of a man's prejudice is more honourable to him than the discovery, or the most successful defence, of any truth. This, however, I must, for the present at least, decline, and leave it to you; contenting myself with the inferior praise of confirming the hypothesis for which I have contended. If, from the politeness habitual to Frenchmen, you should decline this honour, thinking my claim to it better founded than yours, I may hereafter be induced to receive it; but for the present, yielding to you a palm more glorious than that of any victory, and trusting that your political revolution will be more stable than this chemical one, I am, with the greatest respect, Gentlemen, Your fellow-citizen, Joseph Priestley. Northumberland in America, Oct. 22, 1803.[11]

It seems strange to us, perhaps, that Priestley adhered so tenaciously to the phlogiston doctrine and felt so thoroughly convinced of its soundness. But this is because we are already converted to another manner of looking at things; it is because the doctrine is foreign to our way of thinking. Priestley's attitude seems far less strange if we consider what the phlogistonists themselves intended by their doctrine.

The article on combustion in Macquer's "Dictionnaire de Chymie" commences as follows—"Combustion is only the escape of the principle

[10] RÉFLEXIONS SUR LA DOCTRINE DU PHLOGISTIQUE ET LA DÉCOMPOSITION DE L'EAU. Par Joseph PRIESTLEY, D.Ès-Lois, Membre de la Société Philosophique de Philadelphie, &c. Ouvrage traduit de l'Anglais & suivi d'une Reponse par P. A. ADET; Membre de la Société Philosophique de Philadelphie, &c. A PHILADELPHIE, De l'Imprimerie de MOREAU DE SAINT-MÉRY, Première rue Sud, au coin de celle Walnut. **1797.** 96 pp. (Copy in the Harvard College Library.)

[11] "The Doctrine of Phlogiston, etc.," 2nd ed., pp. xiv, xv.

of inflammability which is contained in many sorts of substances, which for this reason are called *combustible substances*. The principle of inflammability is combined in the substances in greater or less quantity and in different manners—and a diversity in the phenomena of combustion is the consequence."[12] The article on phlogiston says—"When phlogiston unites with a non-inflammable substance, a new compound is produced which is neither hot nor luminous, but which, by this union, becomes capable of taking fire, and, consequently, of producing heat and light, more or less easily according to the amount of phlogiston which happens to be united in the new compound and according to the manner in which it is combined."[13] This is saying that combustibility, by combining with a non-inflammable substance, produces a combustible one, more or less combustible according to the amount of combustibility which it contains. When this substance burns, its combustibility leaves it. When a man is fed, his hunger leaves him—more or less readily according to the amount of the hunger and according to the manner in which it is combined within him. There is nothing in this that anyone would care to deny. But it is not the kind of argument that appeals to our present taste.

We can argue about phlogiston as we can about hunger, for both are *unextended entities* of the scholastic metaphysics, *qualities* of the Aristotelian tradition, identical in every logical respect with the things about which Priestley, from his theological training and interest, was accustomed to think. It is somewhat remarkable that this clergyman, who dabbled in chemistry for his own amusement, was able to discover oxygen, to develop methods for the study of gases, and to make observations of fundamental importance to the science, but it is not in the least remarkable that the intelligent clergyman, aware of his own mental processes, adhered to the doctrine of phlogiston. His arguments were valid from his own point of view. But the thinking of chemists was now determined by a different way of looking at things, and his arguments, however sound, were found at the last to be uninteresting.

Bibliographical Note

The pamphlets mentioned in the foregoing article and the papers listed below are believed to constitute all that Priestley wrote and published in America on the subject of chemistry.

Papers in The Medical Repository, New York.

1798. Letter to Dr. Mitchill, in reply to a letter "attempting to accommodate the Dispute among the Chemists concerning Phlogiston." Vol. 1, pp. 521–522.

[12] Macquer, "Dictionnaire de Chymie," 2nd ed., Paris, 1778, vol. 1, p. 389.

[13] Macquer, *Ibid.*, vol. 3, p. 104.

1799. Second letter to Dr. Mitchill. Vol. 2, pp. 45–47.
On Red Precipitate of Mercury, as favourable to the Doctrine of Phlogiston, in a letter to Dr. Mitchill. Vol. 2, pp. 163–165.

Objections to the Antiphlogistic Doctrine of Water; in a letter to Dr. Mitchell. Vol. 2, pp. 166–167.

Experiments Relating to the Calces of Metals; communicated in a fifth letter to Dr. Mitchill. Vol. 2, pp. 263–268.

Of Some Experiments made with Ivory Black, and also with Diamonds; communicated in a sixth letter to Dr. Mitchill. Vol. 2, pp. 269–271.

On the Phlogistic Theory; communicated in a seventh letter to Dr. Mitchill. Vol. 2, pp. 383–387.

On the same subject; communicated in an eighth letter to Dr. Mitchill. Vol. 2, 388–389.

1800. Dr. Priestley's Reply to his Antiphlogistian Opponents. No. I, vol. 3, pp. 116–121. No. II, same, pp. 121–124. No. III, same, pp. 124–127.

1801. Experiments on the Production of Air by the Freezing of Water. Vol. 4, pp. 17–21.

Letter to the Editors Relative to the Reviews of His Books. Vol. 4, p. 103.
Experiments on Heating Manganese in Inflammable Air; in a letter to Dr. Mitchill. Vol. 4, pp. 135–137.

1802. Observations and Experiments Relating to the Pile of Volta; in a letter to Dr. Woodhouse, Professor of Chemistry in the University of Pennsylvania. Vol. 5, pp. 153–159.

Miscellaneous Observations Relating to the Doctrine of Air; in a communication to Dr. Mitchill. Vol. 5, pp. 264–267.

A Reply to Mr. Cruikshank's Observations in Defense of the New System of Chemistry, in the fifth volume of Mr. Nicholson's Journal, pages 1, etc. In a letter to Dr. Woodhouse, Professor of Chemistry in the University of Pennsylvania. Vol. 5, pp. 390–392.

Letter to the Editors on the same subject. Vol. 5, p. 393.

1803. Remarks on Mr. Cruikshank's Experiments upon Finery Cinder and Charcoal; in a letter to the Editors. Vol. 6, pp. 24–26.

Observations on the Conversion of Iron into Steel; in a letter to the Editors. Vol. 6, pp. 158–159.

Additional Remarks on Mr. Cruikshank's Experiments on Finery Cinder and Charcoal; communicated to the Editors. Vol. 6, pp. 271–273.

Papers in the Transactions of the American Philosophical Society, Philadelphia

1799. No. 1. Experiments and Observations Relating to the Analysis of Atmospherical Air. Vol. 4, pp. 1–11.

No. II. Further Experiments Relating to the Generation of Air from Water. Vol. 4, pp. 11–20.

An Appendix to the Two Articles in This Volume, in a letter to B. S. Barton, M.D. Vol. 4, pp. 382–386.

1802. No. I. Experiments on the Transmission of Acids, and Other Liquors, in the Form of Vapour, over Several Substances in a Hot Earthen Tube. Vol. 5, pp. 1–13.

No. II. Experiments Relating to the Change of Place in Different Kinds of Air through Several Interposing Substances. Vol. 5, pp. 14–20.

No. III. Experiments Relating to the Absorption of Air by Water. Vol. 5, pp. 21–27.

No. IV. Miscellaneous Experiments Relating to the Doctrine of Phlogiston. Vol. 5, pp. 28–35.

No. V. Experiments on the Production of Air by the Freezing of Water. Vol. 5, 36–41.

No. VI. Experiments on Air Exposed to Heat in Metallic Tubes. Vol. 5, pp. 42–50.

1809. (Posthumous.) Observations on the Discovery of Nitre, in Common Salt, Which Had Been Frequently Mixed with Snow, in a letter to Dr. Wistar. Vol. 6, pp. 129–132.

Poor High-School Students Can Be Made into College Material. High-school students who make poor grades, but still have a longing for a college education and a willingness to make a special effort to get it, should take heart. Many of those who are willing to go through a preliminary course of training can be made into good college material.

Prof. Edward S. Jones, director of personnel research at the University of Buffalo, told the American Association for the Advancement of Science of results of experiments with a course in testing and training sub-freshmen. Without such a course the poor high-school student has only a small chance of getting through his freshman year. With such preliminary training his chances are greatly increased, Prof. Jones showed.

Of 38 applicants from the lowest two-fifths of their high-school classes, only 6 were eliminated as utterly unfit after an extensive set of examinations. The remaining 32 were given a three weeks' course in "How to Study." The course raised half of the number to the point of being competent college material, able to carry full college schedules without receiving warnings. Practically all of the number appeared to be actually superior to their comrades from the middle fifth of their high-school classes. The most effective types of training were writing English compositions followed by long interviews, extensive drill in forced rapid reading, note-taking drill, speed drill in mathematics, and lectures on how to study.

Results of these experiments at the University of Buffalo suggest the advisability for municipal universities of dealing separately in some such way as this with students from the lowest groups in high schools, Prof. Jones said. The municipal university owes a peculiar pledge to the community and should not, perhaps, take the same strict methods of elimination as a highly endowed college of the older type.—*Science Service*

JOSEPH PRIESTLEY AS AN HISTORIAN OF SCIENCE, WITH SOME ACCOUNT OF HIS PHILOSOPHICAL APPARATUS EXISTING AT THE PRESENT TIME*

C. A. BROWNE, CHIEF, BUREAU OF CHEMISTRY, WASHINGTON, D. C.

Joseph Priestley is in many ways a most interesting figure to students of the history of science. He was not only himself a most eminent natural philosopher, but he was also an ardent student of the history of science, to which subject he made numerous contributions. It is worthy of note that Priestley's earliest scientific book was his "History and Present State of Electricity" which he published in 1767 at the age of thirty-four. The success of this work induced Priestley to form the idea of writing histories upon all the branches of experimental science, and in the continuance of this plan he published in 1772 his "History of Discoveries Relating to Vision, Light and Colours" in two quarto volumes. The expense and labor connected with the publication of this second work caused Priestley to suspend further efforts upon additional histories of science until he had determined the state of public opinion as to works of this kind.

> The pleasure I have in this undertaking (he writes), is not so great but that it will depend upon the reception my labors meet with, whether I continue them or not. If those persons for whose opinion I have an esteem favor me with their approbation and the sale of the work indemnify me for the very great expenses I have been at on account of it, I shall persevere with pleasure. If the reception be unfavorable in these respects I shall certainly desist, and be thankful that I can betake myself to other studies not less agreeable to me.

The expense of putting out the "History of Discoveries Relating to Vision, Light and Colours" was so great that Priestley felt it necessary for purposes of protection to publish it by subscription. The list of subscribers contains 500 names including such celebrities as Jeremiah Bentham, Edmund Burke, Henry Cavendish, John Ingenhousz, Joshua Reynolds and Benjamin Franklin, the latter setting his name down to the generous extent of twenty copies. Franklin, as we know, gave Priestley the fullest support and encouragement in his historical and scientific investigations. His friendship had a great influence upon Priestley's work as a political and scientific writer. According to Sir T. E. Thorpe, "it may be truthfully said that Franklin made Priestley into a man of science."

Many of the subscriptions to the "History of Discoveries Relating to Vision, Light and Colours" were never paid and this fact together with the poor sale of the book caused Priestley to abandon his plan of

* Paper read before the History of Science Society at the Philadelphia meeting of the American Association for the Advancement of Science, Dec. 29, 1926.

writing other works upon the history of the sciences, although he had purchased a great number of books for this purpose. While this abandonment of his original plan was a great loss to the history of science, his preliminary studies in this field were the cause of his applying himself henceforth wholly to original research and the brilliancy of his accomplishments as an experimenter causes no one to regret that circumstances obliged him to make the change.

Priestley expressed clearer and more definite ideas upon the importance of studying science from the historic viewpoint than any previous writer. In many ways he may be regarded as the founder of this department of knowledge and some of the views which he expressed upon the subject deserve to be quoted.

Let histories be written (observes Priestley) of all that has been done in every particular branch of science and let the whole be seen at one view. And when once the entire progress, and present state of every science shall be fully and fairly exhibited, I doubt not but we shall see a new and capital era commence in the history of all the sciences. Such an easy, full, and comprehensive view of what has been done hitherto could not fail to give new life to philosophical inquiries. It would suggest an infinity of new experiments, and would undoubtedly greatly accelerate the progress of knowledge; which is at present retarded, as it were, by its own weight, and the mutual entanglement of its several parts.[1]

. . . . . .

These histories are evidently much more necessary in an advanced state of science, than in the infancy of it. At present philosophical discoveries are so many and the accounts of them are so dispersed, that it is not in the power of any man to come at the knowledge of all that has been done, as a foundation for his own inquiries. And this circumstance appears to me to have very much retarded the progress of discoveries.[2]

. . . . . .

To whatever height we have arrived in natural science, our beginnings were very low, and our advances have been exceeding gradual. And to look down from the eminence, and to see, and compare all those gradual advances in the ascent, cannot but give the greatest pleasure to those who are seated on the eminence, and who feel all the advantages of their elevated situation. And considering that we ourselves are, by no means, at the top of human science; that the mountain still ascends beyond our sight, and that we are, in fact, not much above the foot of it, a view of the manner in which the ascent has been made cannot but animate us in our attempts to advance still higher, and suggest methods and expedients to assist us in our further progress.[3]

. . . . . .

The history of experimental philosophy, in the manner in which it ought to be written, to be of much use, would be an immense work; perhaps more than any one man ought to undertake; but it were much to be wished, that persons who have leisure, and sufficient abilities, would undertake it in separate parts.[4]

[1] "Preface, History and Present State of Electricity," London, **1767,** p. XV.
[2] "Preface, History and Present State of Electricity," London, **1767,** p. VI.
[3] "Preface, History and Present State of Electricity," London, **1767,** p. V.
[4] "Preface, History and Present State of Electricity," London, **1767,** p. VII.

In order to facilitate the advancement of all the branches of useful science, two things seem to be principally requisite. The first is an historical account of their rise, progress and present state; and the second, an easy channel of communication for all new discoveries. Without the former of these helps, a person, every way qualified for extending the bounds of science, labors under great disadvantages; wanting the lights which have been struck out by others and perpetually running the risk of losing his labor, and finding himself anticipated in the discoveries he makes, which is a great mortification and discouragement. In other respects, also, the progress of natural knowledge is retarded on this account; so that, in the present state of science, such histories as these are, in a manner, absolutely necessary.

Considering how very few persons are acquainted with the present bounds of any branch of science, or, indeed, are in circumstances in which it is possible for them to acquire that knowledge, and how much time and labor are even, in that case, necessary, in order to acquire it; it must be allowed that, were those histories judiciously compiled, real discoveries would be much more numerous; and were these again easily and expeditiously circulated, the progress of knowledge might be accelerated beyond what we can now conceive.[5]

It will be interesting to turn from these general observations of Priestley upon the needs, purposes, and rewards of historical scientific studies to a personal account of his own methods as an historian of science.

I have adopted (he writes), the historical method because it appears to me to have many obvious advantages over any other for my purpose; being particularly calculated to engage the attention and to communicate knowledge with the greatest ease, certainty and pleasure. Moreover, the recital of the labors of philosophers in an historical method gives a writer a better opportunity than a systematical method would do, of transmitting them to posterity in such a manner as will operate most powerfully on the minds of the readers and be a motive with them to exert and distinguish themselves in philosophical pursuits. To such considerations as these the mind of man is never wholly insensible.

It will, however, be found, that, though the method I have chosen be historical, it is, at the same time, sufficiently systematical; and, indeed, pretty strictly so with respect to each distinct article in the several periods into which the work is divided; so that any person, if he choose it, may see, without interruption, all the discoveries that have been made relating to any single head or division of every subject. In order to be more systematical, and thereby to make the work more useful to young students, I have imitated the conduct of the best civil historians in making the order of time give place, with respect to many articles, to more natural, and therefore more important connections. Thus, when later writers have added but little to the observations of those who preceded them, I have given the whole of a subject in an earlier period, and when former writers contain very little, I have given the whole in a later period. This method cannot but be more agreeable to all my readers than a mere journal, or a strictly chronological narrative of transactions.[6]

. . . . . .

At the close of each part of the history, I shall endeavor to give a comprehensive view of all the discoveries which have been made in that branch of science to which it is ap-

[5] "Preface, History and Present State of Discoveries Relating to Vision, Light and Colours," London, 1772, p. I.

[6] "Preface, History and Present State of Discoveries Relating to Vision, Light and Colours," London, 1772, p. VII.

propriated, pointing out their natural connection, noting what I shall imagine to be the principal desiderata, and giving hints for the extension of it. To each volume I shall also subjoin an explanation of all the technical terms that occur in it; and, in order to give a clearer view of the progress of the science, I shall, whenever it can be done conveniently, exhibit a view of all those persons who have made the greatest figure in the history, after the manner of my *Chart of Biography*.[7]

. . . . . .

Every new fact, or important circumstance, I have noted as it arose; but I have abridged all long details, and have carefully avoided all digressions and repetitions. For this purpose, I have carefully perused every original author, to which I could have recourse; and every quotation in the margin points to the authority that I myself consulted, and from which the account in the text was actually taken. Where I could not procure the original authors, I was obliged to quote them at second hand, but the reference will always show where that has been done. That I might not misrepresent any writer, I have generally given the reader his own words, or the plainest translation I could make of them; and this I have done, not only in direct quotations, but where, by a change of person, I have made the language my own.

I have made it a rule to myself, and I think I have constantly adhered to it, to take no notice of the mistakes, misapprehensions and altercations of electricians; except so far as, I apprehended, a knowledge of them might be useful to their successors. All the disputes which have no way contributed to the discovery of truth, I would gladly consign to eternal oblivion. Did it depend upon me, it should never be known to posterity, that there had ever been any such thing as envy, jealousy, or cavilling among the admirers of my favorite study. I have, as far as my best judgment could direct me, been just to the merits of all persons concerned. If any have made unjust claims by arrogating to themselves the discoveries of others, I have silently restored them to the right owner and generally without so much as giving a hint that any injustice had ever been committed. If I have, in any case, given a hint, I hope it will be thought, by the offending parties themselves, to be a very gentle one; and that it will be a *memento* which will not be without its use.[8]

It will be seen from these quotations how thoroughly Priestley, in his pioneer work, had reflected upon the duties of the historian of science and how modern his views appear in many of their present-day applications.

Priestley's life and work have an especial interest to American scientists, for after his exile from England the last ten years of his life from 1794 to 1804 were passed at Northumberland, Pennsylvania. The house which he built at the junction of the two branches of the Susquehanna River is still in perfect preservation and was dedicated on the fifth of last September as a permanent memorial. Close to this house there has been erected, by the liberality of certain alumni of the Pennsylvania State College, a fireproof museum for containing manuscripts, books, apparatus and other memorabilia of the famous scientist. In addition to the collection at Northumberland, many pieces of the existing apparatus

[7] "Preface, History and Present State of Discoveries Relating to Vision, Light and Colours," London, 1772, p. VIII.

[8] "Preface, History and Present State of Electricity," London, 1767, p. IX.

from Priestley's Northumberland laboratory are deposited at Dickinson College, Pennsylvania, and at the Smithsonian Museum in Washington. It is to the history and present condition of some of this apparatus that I wish to devote the remaining portion of this paper.

Priestley's interest in science, as may be inferred from his writings, was not confined to chemistry alone, but was of a much more general character and embraced electricity, optics, meteorology, physics, astronomy, surveying, and navigation. This wide range of Priestley's scientific interests is reflected in the character of the apparatus which he used in his experiments. In an inventory of Priestley's property which was destroyed by the rioters at Birmingham in 1791, there is noted under Section 5 the following heading, "A Schedule Inventory and Appraisement of the Philosophical Instruments, Electrical Apparatus, Optical Instruments, Mathematical Instruments, Chymical Apparatus and Chymical Substances Belonging to the said Plaintiff being in and about his said Dwelling House and Outhouses and being wholly or in part destroyed and demolished by the Rioters."[9]

There are mentioned in this inventory thermometers, barometers, hygrometers, air pumps, magnets, electrical machines, microscopes, telescopes, compasses, globes, an orrery, a magic lantern, a theodolite, a sector, a pyrometer, burning lenses, balances, furnaces, retorts, flasks, crucibles, bell jars, eudiometers and other miscellaneous apparatus to the total value of 605 pounds and 2 shillings. It is fortunate that so complete and detailed a list of the apparatus in Priestley's Birmingham laboratory has been preserved. Many of the instruments in the inventory had been given to Priestley by his numerous friends and admirers who were equally zealous in helping him at his new home in Hackney to replace the apparatus which was destroyed by the rioters in Birmingham.

Priestley's laboratory consisted of a small one-story building that was attached to his residence as a wing and it was here that he placed the extensive collection of apparatus which he brought from England. One wonders in contemplating the existing remnants of this equipment at the immense labor which must have been spent in transporting over rough trails so many pieces of large and fragile apparatus into the heart of what was then a wilderness. Unfortunately, there is no inventory of this Northumberland apparatus such as exists for Priestley's Birmingham laboratory. We know, however, that the Northumberland laboratory was equipped along the same broad scientific lines as the Birmingham laboratory; indeed, the existing evidence indicates that it was virtually a replica of the latter.

[9] A complete inventory of Priestley's Birmingham laboratory is published on pages 221–234 of H. C. Bolton's, "Scientific Correspondence of Joseph Priestley," New York, 1892.

After Priestley's death in 1804 his laboratory and apparatus seem to have been left for a number of years in their original condition. Doctor Thomas Cooper, an English liberal of broad education and considerable scientific ability who had followed Priestley to Northumberland, made use of the laboratory after its owner's death, and in 1811 performed a research there upon the production of potassium from caustic potash. In this same year Cooper accepted the professorship of chemistry in

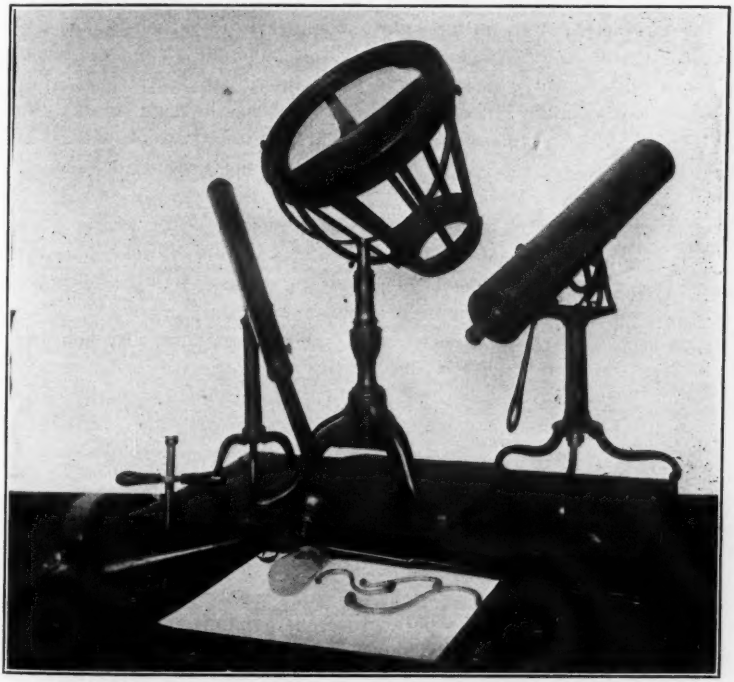


FIG. 1.—Some of the Priestley Apparatus in the Dickinson College Collection.

Dickinson College at Carlisle, Pennsylvania, and in entering upon his new duties negotiated with Priestley's son for the purchase of some of his father's scientific apparatus by the trustees of the college. The transaction is recorded in the minutes of the trustees of Dickinson College for December 17, 1811, in the following words:

> Resolved that the Trustees will accept on the terms proposed by Mr. Priestley (son of the great Priestley) a three-foot reflecting telescope, five-inch reflector, mounted in the best manner, $220; a lense, $250, and air gun, $60, and that the amount be paid out

of the apparatus fund, and that Mr. Cooper be requested to inform Mr. Priestley of this resolution and that his draft will be duly honored.

The instruments which were thus purchased, together with other apparatus acquired by Doctor Cooper from the Priestley estate, are still preserved in the museum of Dickinson College. The collection is described in a little, illustrated pamphlet published by Doctor Charles F. Himes, professor in Dickinson College from 1865 to 1896.

The chief item of interest in the Dickinson College collection[10] (Fig. 1) is the large compound burning glass, composed of two lenses, the larger 16 and the smaller 7 inches in diameter. The heavy metal frame is pivoted on a stand which permits the adjustment of the glass to any position of the sun. This glass was used by Priestley as a source of heat in his chemical experiments and is similar to the one which was used by him in the classic experiment of 1774, when mercuric oxide, placed in the focus of the two lenses, was decomposed with the evolution of oxygen. This piece of apparatus was sold by Priestley's son to Dickinson for $250.00.

Priestley's air gun, acquired by Dickinson for $60, is also shown in the photograph of the Dickinson collection apparatus. It is a well-finished, beautiful instrument which fired a bullet weighing 45 grains. The air magazine consists of an iron globe $3\frac{1}{2}$ inches in diameter which can be unscrewed from the barrel of the gun and charged with air by attaching to a compressor, also shown in the illustration. The magazine, holding air enough for about twelve shots, is then rescrewed to the gun and fired by pressing the trigger which releases enough air for a single discharge. There is a tradition that Priestley hunted deer with this air-gun in the neighborhood of Northumberland. In the old days at Dickinson College the senior class had an annual target practice with Priestley's air-gun, but this custom has long been discontinued.

The reflecting telescope sold by Priestley's son to Dickinson for $220 (shown at the right in the photograph) is a handsome instrument and still in excellent condition. The reflecting mirror, 5 inches in diameter, is contained in a strong brass tube, $2\frac{1}{2}$ feet long, the whole being well mounted upon a brass tripod. This apparatus bears the name of the maker "W. & S. Jones, 135 Holburn, London."

Dickinson College also possesses a fine achromatic refracting telescope that belonged to Priestley. The instrument (shown at the left in the photograph) is 4 feet long and is important historically, as it was made by John Dollond, the first manufacturer to produce an achromatic lens.

According to Professor Himes, an orrery of Priestley was also acquired by Dickinson College. The instrument, however, was not in working

[10] We are indebted to President J. H. Morgan of Dickinson College for the photograph of the Priestley apparatus preserved at Carlisle, Pa.

condition and, undergoing a gradual disintegration in the course of years, has now completely disappeared.

The Dickinson collection of Priestley apparatus also contains a flask of heavy glass with ground openings adapted to fit the ground ends of various heavy, curved glass tubes. This flask and its tubular connections are similar to those described in Priestley's publications upon the gases.

The apparatus remaining in Northumberland, after the acquisition of the pieces by Dickinson College, continued in the possession of Priestley's

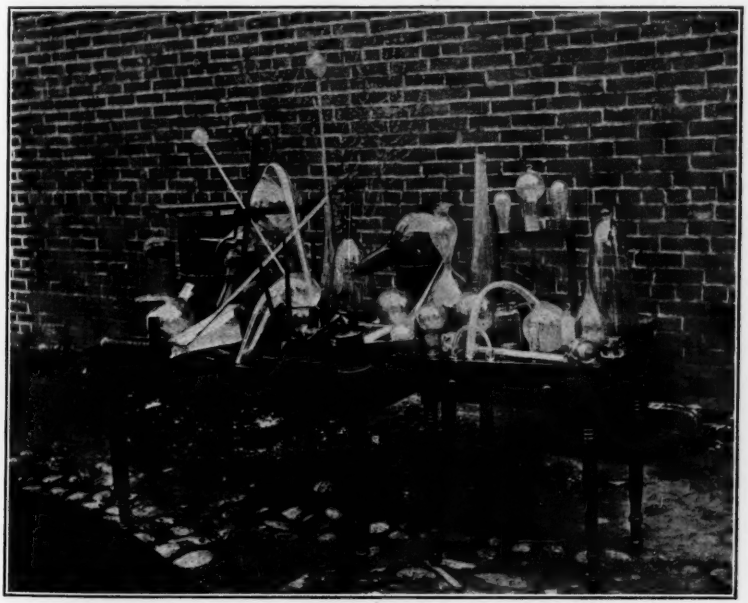


FIG. 2.—Chemical Apparatus of Dr. Joseph Priestley Exhibited at the Northumberland Anniversary on Aug. 1, 1874. Photograph by Prof. L. H. Laudy, Columbia College School of Mines.

descendants. Upon the return of Joseph Priestley, 2nd, to England, the apparatus and library of his father were entrusted to Dr. Thomas Cooper for sale, but it is uncertain what transactions were effected by him in this connection. The apparatus was probably stored in Northumberland but I have been unable to trace its history during this period. Joseph R. Priestley, the son of Joseph Priestley, 2nd, and grandson of the discoverer of oxygen, came to America at the age of 19 and took up his residence in Northumberland, where he acquired possession of his grandfather's relics. There is a family tradition that when he moved from

his farm in Tuckahoe Valley to Northumberland, the horses ran away with the wagon in which some of the apparatus was packed and many valuable pieces were broken. When Joseph R. Priestley died in 1862, many of his grandfather's effects were sent to his sisters in England, but I have been unable to determine whether any apparatus was included in this shipment. The possessions of the great chemist that still remained after this division passed to Doctor Joseph Priestley, 4th, son of Joseph R. Priestley and great-grandson of the discoverer of oxygen.

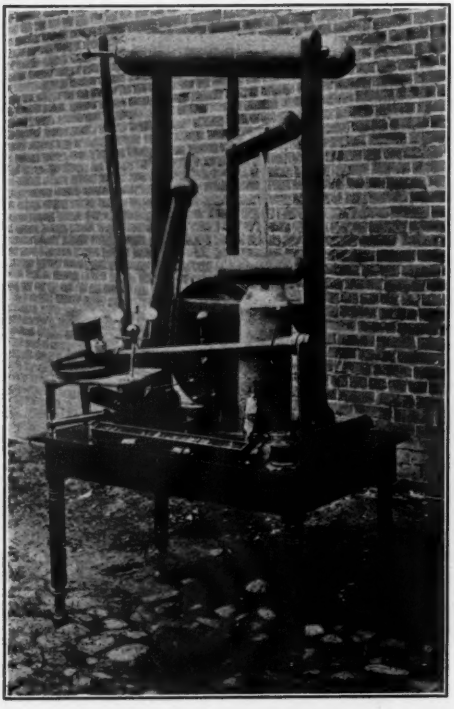


FIG. 3.—Electrical Apparatus of Dr. Joseph Priestley Exhibited at the Northumberland Anniversary on Aug. 1, 1874. Photograph by Prof. L. H. Laudy, Columbia College School of Mines.

On August 1, 1874, at the time of the celebration of the 100th anniversary of the discovery of oxygen by Priestley, the various pieces of his apparatus that still remained in Northumberland were photographed by Professor L. H. Laudy of the Columbia College School of Mines, and the collodion negatives which he made are still in existence in the Chandler Chemical Museum of Columbia University, in a perfect state of preservation. Three of the photographs here reproduced are recent prints from these old negatives.

The first (Fig. 2) shows two tables of chemical apparatus consisting of bell jars and connections, retorts, glass bottles, flasks, tubular connections, a balloon-shaped vessel of dark glass, parts of a laboratory furnace, crucible tongs, a large, metal tripod, a balance in a glass case, water baths, and various other utensils of uncertain character.

The second photograph (Fig. 3) shows a table of some of Priestley's electrical apparatus consisting of a large electrical machine with wheel

in a wooden frame, an insulating stand with four glass legs, a large cylindrical insulator of wood for holding charged objects, a heavy glass rod attached to a metal cylinder which was probably used for generating static electricity by rubbing, an insulated electric jar, various insulated supports with rods and balls, metal holders with points for discharging electric sparks, and various other miscellaneous parts. This photograph also shows a long box of slides for microscopic observation.

The third photograph (Fig. 4) shows a collection of Priestley's optical and astronomical apparatus, consisting of two telescopes, several micro-

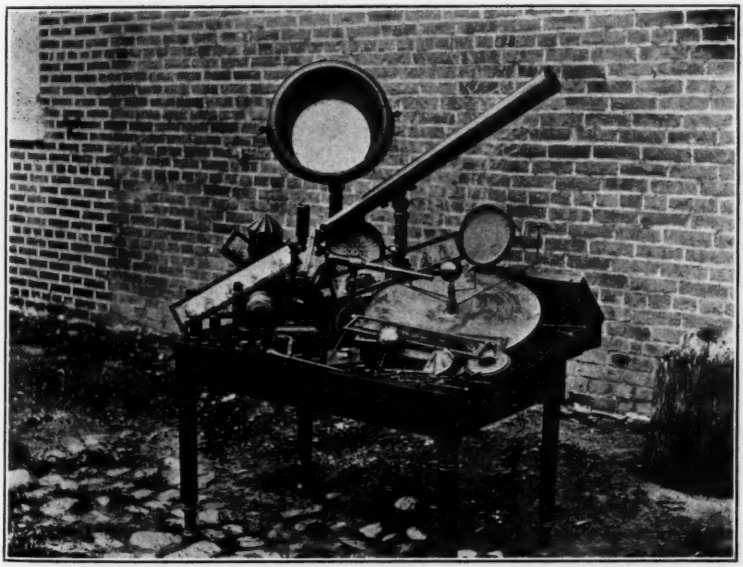


FIG. 4.—Optical, astronomical, and other philosophical apparatus of Dr. Joseph Priestley exhibited at the Northumberland Anniversary on Aug. 1, 1874. Photograph by Prof. L. H. Laudy, Columbia College School of Mines.

scopes and microscopic attachments, a magic lantern with several lantern slides, several compass cases with cards, a globe, an orrery with the sun and five planets, a mounted frame containing the chart of a planetarium, and numerous miscellaneous small fittings of unknown character.

The scientific apparatus shown on these plates taken by Professor Laudy over fifty-two years ago is of the same general character as that listed in the Birmingham inventory of 1791, and shows that Priestley, in fitting up his Northumberland laboratory, followed, as was natural, the original English plan of equipment. Various small minor pieces of

Priestley's apparatus were given to some of the chemists who attended the centennial meeting at Northumberland in 1874.

Shortly after the death of Doctor Joseph Priestley, 4th, at Northumberland in March, 1883, Doctor Spencer F. Baird, Secretary of the Smithsonian Institution, and a distant family connection, wrote to his widow as follows:

SMITHSONIAN INSTITUTION,
Washington, D. C., April 24, 1883.

Dear Madam:

It was with very great regret that I heard of the death of Dr. Joseph Priestley, appreciating not only the loss to his family but to the world at large. As a distant connection, I claim the right of personally expressing this same regret.

I would not venture to intrude upon you at present in a matter of business, but for the solicitation of eminent gentlemen who are extremely desirous that the philosophical apparatus in the possession of Dr. Priestley, and descended to him from his distinguished ancestor of the same name, should be held as one of the sacred relics in the history of American science. Concurring heartily with this desire, I now beg to say that if you will entrust this apparatus to the Smithsonian Institution, it will be accorded a prominent place in the historical department of the National Museum where it can be exhibited and appreciated in a thoroughly fireproof building. The National Museum is the finest edifice of this kind in America, and perhaps in the world, and has a considerable collection of precious articles in it. We have just had transferred to us the entire collection of Washington and Franklin articles formerly in the Patent Office; and are continually receiving similar articles, on account of the safe custody that we can assure. The philosophical and chemical apparatus, however, to which I have referred, will form part of a collection illustrating the evolution of chemical and physical science, so far as apparatus is concerned, and be a suitable introduction to a display of all the more modern devices for such investigations.

Yours truly,

(signed) SPENCER F. BAIRD,
Secretary S. I.

Mrs. Dr. Joseph Priestley,
Northumberland, Pa.

The surviving heirs expressed their willingness to this transfer and a large part of the scientific apparatus of the famous Priestley, which still remained in Northumberland, was sent to the Smithsonian Institution.

The inventory of the apparatus received by the Smithsonian Institution from Miss Priestley, Northumberland, Pa., on July 5, 1883, consisted of the following:

Acc. No. 13305, received July 5, 1883, from Miss Priestley, Northumberland, Pa.:

Photograph of the statue of Priestley at Birmingham, England	Glass globe
Brass reflector and stand	Flask with green glass
Stand with pendulum	Alembic glass
Orrery with stand	Alembic glass, large
	5 bell jars

Compass box
Electrical apparatus
Galvanometer
Apparatus
Apparatus with Leyden jar
Leyden jar with brass lid
Box of tubing with parts of apparatus
Large collection of fragments of glass, iron and wooden apparatus

Of the apparatus deposited in the Smithsonian Institution by other Priestley heirs "a brass disc with glass handle for electrical experiments"

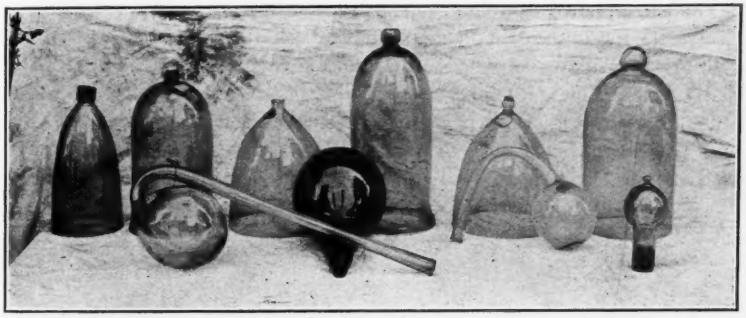


Fig. 5.—Bell-jars, retorts, and other glass apparatus of Dr. Joseph Priestley in the National Museum, Washington, D. C. Some of this apparatus is shown in Fig. 2.

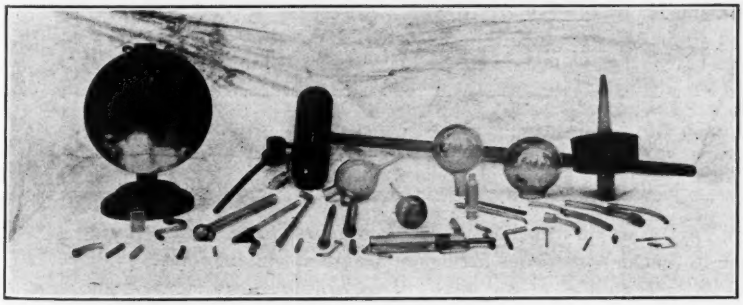


Fig. 6.—Various pieces of chemical and physical apparatus of Dr. Joseph Priestley in the National Museum, Washington, D. C. Some of those pieces are shown in Figs. 2 and 3.

was received on May 1, 1893, from Mrs. Dr. Thomas Lyon of Williamsport, Pa., and two large globes and stands were received on May 25, 1893, from Mrs. Eliza R. Lyon of Williamsport, Pa.

With the kind permission of the Smithsonian Institution I have had photographs made of as many of the pieces of the Priestley apparatus as could be found and these are shown in Figs. 5, 6, and 7.

The first photograph (Fig. 5) shows six bell jars of various construction.

two retorts, a small globular receiver with wide neck and a balloon-shaped vessel of dark glass.

The second photograph (Fig. 6) shows various flasks and miscellaneous pieces of glass tubing, connections, etc.; a concave, copper reflector mounted upon a stand; a heavy glass rod attached to a metal cylinder which was perhaps used for generating static electricity; and various other utensils which were probably employed in electrical experiments.

The third photograph (Fig. 7) shows other apparatus of a miscellaneous electrical, mechanical, and astronomical character. There is a large cylindrical insulator of wood; an insulating stand shown in Fig. 3, but with two of the glass legs missing; an orrery (shown in Fig. 4 but now in a much greater state of deterioration); a compass card and case; the chart of a planatarium for the years 1752–1800, the year 1801 being written in with ink, very possibly by Priestley himself; and some forty small

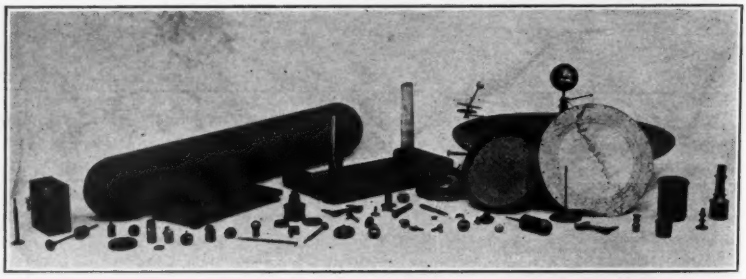


FIG. 7.—Various pieces of electrical, astronomical, and other philosophical apparatus of Dr. Joseph Priestley in the National Museum, Washington, D. C. Some of these pieces are shown in Figs. 3 and 4.

pieces of apparatus consisting of weights, balls, gears, thumb screws, and other miscellaneous fittings of an unknown character.

A large number of the pieces of apparatus shown in these photographs of the Priestley apparatus in the Smithsonian collection can be recognized in Professor Laudy's photographs which were taken at Northumberland in 1874. Some articles are missing which I have been unable to trace and there are some pieces in the Smithsonian collection, such as the copper reflector, which I have been unable to identify in the Northumberland photographs.

Owing to the lack of available space in the National Museum for adequately exhibiting the Priestley apparatus, the Smithsonian authorities have kindly consented to deposit all this material in the Priestley Museum at Northumberland as an indefinite loan. The Assistant Secretary, Dr. A. Wetmore, writes me in this connection as follows: "Until the

National Museum has more space for an exhibit of physical apparatus, it appears that these relics will find better use in the museum established for Priestley in his old home than stored here in the national collections." This decision of the Smithsonian authorities will, I am sure, meet with the hearty approval of all who are interested in the history of American science.

Not all of Priestley's philosophical apparatus remaining in Northumberland at the death of his great-grandson was transferred to the Smithsonian Institution. Some important pieces were retained by the heirs or afterwards given to friends of the family. The telescope, microscope, microscopic sections, magic lantern, and lantern slides, which are shown in Professor Laudy's pictures of 1874, were retained in Northumberland by Miss Annie Priestley, the great-great-granddaughter of Joseph Priestley. She died in 1922, the last of the Priestley name to live in Northumberland. The apparatus which she left at her death and Priestley's balance, which had previously been given to Professor Edgar F. Smith, were afterwards exhibited to the public in the John Harrison Laboratory of Philadelphia, under the auspices of the Priestley Club of the University of Pennsylvania. At this exhibition a lecture was given upon Joseph Priestley by his great admirer, Professor Smith, who has done more than any other American to help perpetuate the great name and fame of Priestley. Last September the apparatus shown at this exhibition was returned with many other memorabilia of Priestley to Northumberland to find a permanent home in the recently dedicated Priestley Museum.

It remains to mention one other important historic piece of apparatus and that is the large air pump which was brought by Doctor Priestley to the United States in 1794 and was in later years acquired by the Franklin Institute of Philadelphia where it is now exhibited (Fig. 8).[11] The pump is attached to the framework of a well-constructed table; the piston is driven by a ratchet operated by a gear and crank which are mounted upon two pillars at one end of the table. At the opposite end of the table is a large column which holds the platform for supporting the vessel to be exhausted. The air is removed from the vessel by a tube leading from the platform to the bottom of the pump cylinder underneath the table. A replica of this famous air pump of Doctor Priestley was exhibited at the recent Sesquicentennial Exposition in Philadelphia.

Such, in brief, is the history of the remaining fragments of the philosophical apparatus collected by Joseph Priestley at Northumberland between 1794 and 1804. In its time it was undoubtedly the most important general collection of the kind existing in the United States. From the instruments which remain of this magnificent equipment we can form

[11] We are indebted to Mr. Howard McClenahan, Secretary of the Franklin Institute, for the photograph of Priestley's air pump.

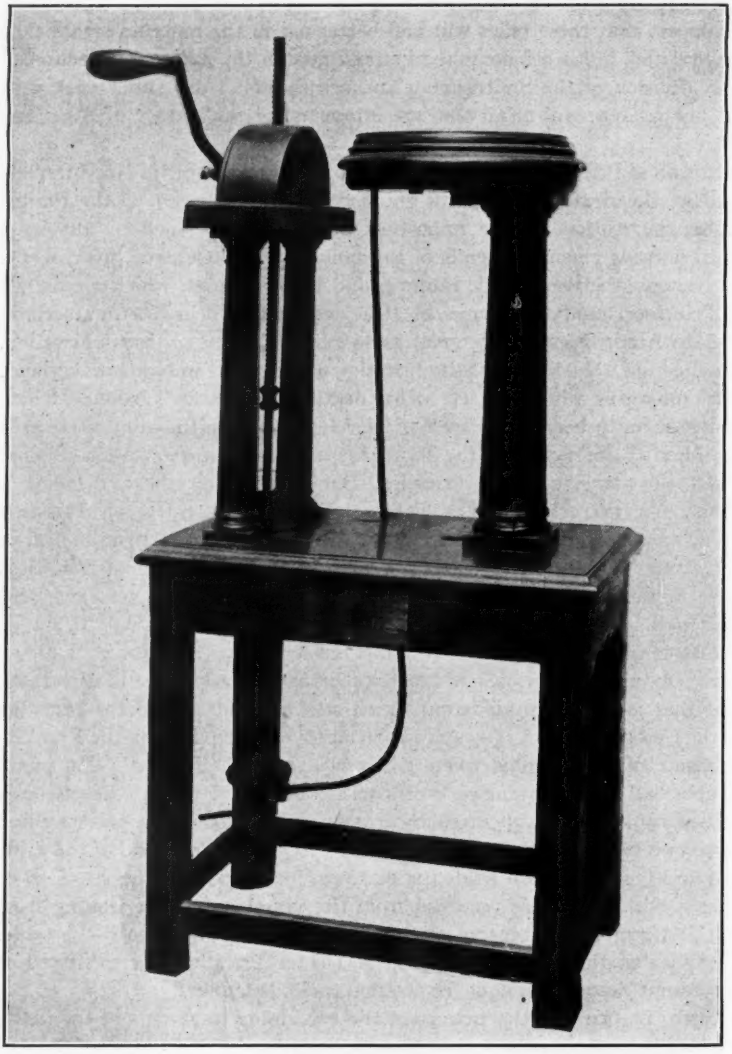


FIG. 8.—Priestley's Air-Pump. Presented about 1848 by Dr. Priestley's family to Charles Sellers. Reclaimed and preserved from destruction by Dr. Coleman Sellers. Presented to the Franklin Institute by the latter's sons, Messrs. Horace Wells and Coleman Sellers, Jr., 1920.

some idea of the great breadth of Priestley's scientific interests. To the student of Priestley's life and works a survey of this apparatus is only an additional confirmation of what Frederic Harrison terms "the immense range of his curiosity." This apparatus constitutes a great landmark in the history of science, not only in America but in the whole world. When we consider all that it has undergone with the vicissitudes of time, it is remarkable that so much of it has come down to us, and this has been due in no small measure to the excellent construction of the apparatus itself. In order that posterity may continue to share the benefit of this priceless inheritance, it is hoped that so far as possible all the existing apparatus which belonged to Priestley may eventually be restored to its old home at Northumberland.

Measure Heatless Light of Fungi and Fireflies. The "cold light" of living things, such as fireflies and the bacteria and fungi that cause rotten wood to glow in the dark, has been made the subject of scientific measurement by Dr. W. W. Coblentz and Dr. C. W. Hughes of the U. S. Bureau of Standards. These humble organisms are so much more efficient in getting light out of a given amount of energy than the best incandescent lamp which man has yet devised that they are at once the admiration and the despair of scientists, and they may some day furnish a hint that will revolutionize the whole art of illuminating engineering. For this reason physicists and biologists are always at them, trying to pry open their secret.

In their present study, the two government scientists have split up the light of these organisms by means of a spectroscopic prism to learn accurately of what colors it is composed, and they have also measured the amount of energy in each of the color bands with a device that makes use of a sensitive photographic plate. The photographic exposures necessary varied from an hour in the case of the firefly to three days with pieces of "fox-fire" wood.

They found that the various organisms varied widely in the range of colors that go to make up their light, as well as in the particular color most intensely present in the glow. Thus, the light of "fox-fire" wood, which comes not from the wood but from a fungus in it, included all colors from blue-violet down to red-orange, with the highest intensity in the green, and a smaller high point in the yellow. In a certain glowing sea-creature the range shifted toward the violet end of the spectrum, going beyond the light of the "fox-fire" and almost to the limit of visibility, but stopping short at orange and excluding red at the lower end. The point of highest intensity for this animal's light was a slightly greenish blue. The firefly with which they experimented had an uneven distribution of color in its spectrum, but was strongest in the yellow. They also tested certain zinc compounds that glow in the dark, for purposes of comparison.

The light from these glowing animals and lowly plants does not come from a slow combustion of their substance, as was once supposed, but from a sort of digestive process which involves a special material secreted by the organism and a special enzyme that works upon it and causes it to shine, according to Prof. E. N. Harvey of Princeton, who has studied this phenomenon of "bioluminescence" from the biological point of view. When these two things come into contact, other conditions being favorable, the light appears. It is also possible to take the "luciferin" of one animal and cause it to glow by adding the enzyme, or "luciferase," of a different species.—*Science Service*

PHOTOGRAPHY AS A RECORDING MEDIUM FOR SCIENTIFIC WORK.* PART II

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4. PHOTOGRAPHY IN OTHER SCIENCES

A. Geology and Geography

Records have been made of different strata from identical viewpoints over a period of years by geology departments in many American universities. A study of the movement of glaciers, terminal moraines, the position of rivers, weathering of rocks, formation and destruction of deltas, and many other phenomena are of great value in constructing our ideas of geological formations. Vulcanism provides an excellent field for photographic study. Many beautiful pictures have been reproduced in the *National Geographic Magazine* of volcanic eruptions, hot spring formations, and lava deposits. In the work of the U. S. Geodetic Survey, photographs provide a useful supplement to the measurements of the engineer. Besides ordinary photography, certain recording instruments have been developed such as the seismograph for determining the magnitude and location of earth tremors. The instruments located at Georgetown University, Washington, D. C., and at the Carnegie Institute, Pasadena, Cal., use the photographic emulsion as the recording medium.

B. Psychology

In a study of the reactions of the eye to light stimuli, Reeves[91] has used both flashlight photography and motion pictures in measuring the rate of expansion and contraction of the pupil. A somewhat analogous investigation on the reflex action of the eyeball has been made by Miles and Shen[92] who used film to record the image of the crater of a carbon arc reflected either from the cornea of the eye or from tiny mirrors on the eyelids. Bott[93] has also used photographic records in connection with an analysis of the law of orientation in stereoscopy.

C. Astronomy

Without the photographic record, the majority of data gathered by astronomers during the past half century would never have been obtained.

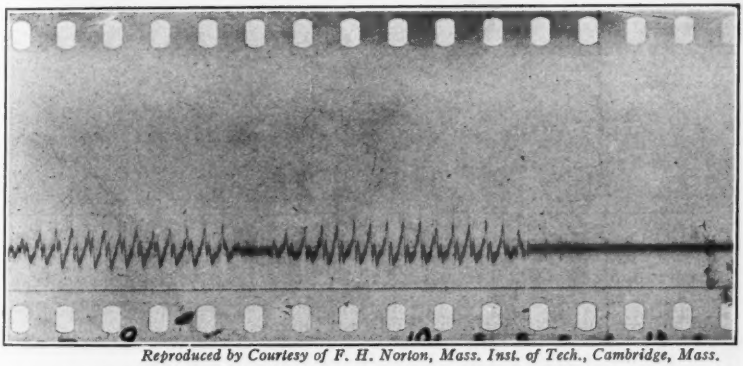
* Delivered before the Division of Chemical Education of the A. C. S. at Philadelphia, September 7, 1926.

[91] *Psychol. Rev.*, **25**, No. 4, 330 (July, 1918); *Trans. Optical Soc.* (London), **22**, 1 (1920–21).

[92] *J. Exptl. Psychol.*, **8**, 344 (1925).

[93] *Ibid.*, **8**, 278 (1925).

It has proved invaluable as a method of determining the size, composition, color, and location of the stars and other heavenly bodies. Very useful data are obtained from eclipse photographs especially in relation to a study of Einstein's relativity theory. An interesting illustrated popular article on this subject was recently published by Showalter.[94] A method of daylight photography of stars down to the 6.5 magnitude at 90° from the sun and to the third magnitude at 20° from the sun has



Reproduced by Courtesy of F. H. Norton, Mass. Inst. of Tech., Cambridge, Mass.

FIG. 7.—Oscillographic record of vertical accelerations. Left record (No. 9) is that of a person walking with rubber heels on a hard floor; right record (No. 10) similar except that leather heels were used. The record is motion-picture film and has a scale of 1 gram for each one-tenth inch. Apparatus may also be used to study loads on airplane wings, shock absorbers, to test the riding qualities of automobiles, tremors in buildings caused by distant traffic, bridge vibrations, and many other linear movements. See reference 87, p. 21 (Jan., 1927).

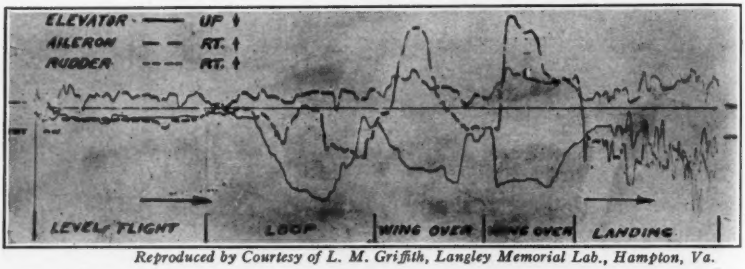
been reported by Hamy.[95] Davidson[96] has described the different instruments used in astronomical photography which include the astrographic telescope, reflecting telescope, photoheliograph, the spectroheliograph, and others.

D. Engineering

In aeronautical work, oscillography has been used to analyze many types of motion. An example is the oscillation of electrical current in a magneto of an airplane engine. Pressure-recording devices using photographic film have been devised by the Langley Memorial Aeronautical Laboratory, Langley Field, Hampton, Va., and described in reports

[94] *Natl. Geog. Mag.*, **47**, 97 (1925).
[95] *Compt. rend.*, **181**, 407, 1026 (1925).
[96] "Photography as a Scientific Implement," Van Nostrand, New York, **1923**, p. 209.

from that institution.[97] A continuous curve may thus be plotted of the angular position of the control surfaces of a plane during steady flight, acrobatics, and landings. (See Fig. 8.) Many otherwise obscure details of piloting technic are thus made available for instruction of future pilots. An instrument known as the "Thirty Capsule Recording Manometer" measures the air pressure exerted on different parts of the wings.



Reproduced by Courtesy of L. M. Griffith, Langley Memorial Lab., Hampton, Va.

FIG. 8.—Oscillograph record of position of airplane controls. Pressure on a diaphragm is optically recorded on moving strip of film. Three records are made simultaneously of the angular position of different control surfaces of an airplane during flight and acrobatics. See reference 97, below.

Reproduced by Courtesy of L. M. Griffith, Langley Memorial Lab., Hampton, Va.

FIG. 9.—Oscillographic record made with thirty capsule recording manometer. Thirty records are made simultaneously on moving film of the pressure at various points on airplane wings during maneuvers. Comparison of Figs. 7, 8, and 9 show various types of oscillographic records. See reference 97, below.

Holes drilled at various points are connected by rubber tubes with a thin metal diaphragm which bulges in proportion to the pressure exerted, the change being recorded on a moving film by light reflected from mirrors on the diaphragm. (See Fig. 9.)

In research on heavy oil fuels for airplanes a special camera has been

[97] *Tech. Notes. Natl. Advisory Comm. for Aeronautics*, Nos. 64, 100, 112, 150, 154, and 156.

devised which is capable of taking pictures of jets of oil at a rate of more than 3500 exposures per second. Recently at McCook Field, Dayton, O., pictures were taken with an ultra-rapid (8 times normal speed) motion-picture camera on panchromatic film of airplanes crashing against a concrete wall to determine the point on the engine where flame initiates after the crash. These records were made in order to improve on engine design to reduce the explosion hazard.

The increase in sensitivity of aerial film to red and infra-red light has made possible photography through haze and is also of great assistance in conjunction with filters in the differentiation between various types of foliage and for detection of camouflage.[98]

X-ray analysis has provided an excellent means of detecting flaws in airplane spars and in other metal and wooden parts of the plane. Kaye[99] has described a number of examples of this type of work. Improvements in aerial camera design and the production of hyper-sensitized aerial panchromatic film have brought aerial photography to a much higher plane of precision. Laws[100] has given a useful survey of the whole subject of cameras, films, and plates, methods of processing, and the uses of aerial photographs. Early accounts of balloon photography have been written by Tissandier[101] and Miethe.[102] Later books on the entire subject have been published by Neumann,[103] Carlier,[104] Clerc,[105] and Ives.[106]

Ground and aerial surveying instruments have been in use for over twenty years which use films or plates for recording purposes. Flemer[107] has described several models of the phototheodolite which is used for stereophotographic surveying. The instrument works similarly to other surveying instruments on a triangulation basis, photographs being made from definite points and at determined angles from a chosen base. The position and height of the triangulation points are then calculated and plotted. Contours and topography may be drawn in on the photographs. Recent improvements and a description of new types of photographic surveying apparatus have been described in the pamphlet, "Terrestrial and Aerial Stereophotographic Surveying."[108] Other handbooks and texts

[98] "Aerial Haze and Its Effect on Photography from the Air," Mono. No. 4, Eastman Kodak Co., Van Nostrand, New York, 1923.

[99] "Practical Applications of X-Rays," Chapman & Hall, London, 1922.

[100] "Photography as a Scientific Implement," Van Nostrand, New York, 1922, p. 401.

[101] "La Phot. en Ballon," Gauthier-Villars, Paris, 1896.

[102] "Phot. Aufnahmen vom Ballon," Knapp, Halle, 1909.

[103] "Die Deutsche Luftstreitkräfte in Weltkriege," Mittler & Sohn, Berlin, 1920.

[104] "La Phot. Aerienne," Librairie Delagrave, Paris, 1921.

[105] "Applications de la Phot. Aerienne," Doin et fils, Paris, 1920.

[106] "Airplane Photography," Lippincott, Philadelphia, Pa., 1920.

[107] "Phototopographic Methods and Instruments," Wiley & Sons, New York, 1906.

[108] "Maatschappy voor Landopmeting," The Hague, 1922.

on the subject have been written by Steiner,[109] Knoppe,[110] Gerard,[111] H. and J. Vallot,[112] and Paganini.[113] The panoramic camera has found special application according to Bagley[114] for topographic surveying. Aerial photographs have been used for archeological exploration.[115]

Map making from the air is usually done by vertical photography, the plane flying back and forth over a territory while making successive exposures, the prints from which are joined up by overlapping them to form a mosaic. This is rephotographed to obtain a single negative of the region surveyed. Aerial surveying provides a rapid means of gaining a knowledge of an uncharted section and assists considerably in reducing the time necessary for subsequent ground surveys. Wilcox[116] and Matthes[117] have discussed the value of aerial surveys with reference to locating petroleum fields. Winterbotham, MacLeod, and Hotine[118] have dealt with several aspects of the subject in papers presented before the British Optical Society. An apparatus for making contour maps from aerial photographs has been described by Nistri[119] which projects two photographs from two mobile projectors so that four reference points in the projected images coincide with positions as drawn to scale in three dimensions. Hugershall and Cranz,[120] and Jones and Griffiths[121] have written general books on the subject.

Engineers have been experimenting for many years in conjunction with photo-physicists to perfect a method for telephonic transmission of photographs. The most successful results which have recently appeared involve a piece-by-piece dissection of the photograph accomplished by passing a tiny beam of light through the film image, the density variations giving rise to fluctuations in the intensity of the transmitted beam. These light fluctuations are converted to electrical impulses which are

[109] "Die Phot. im Dienste des Ingenieurs," Lechner's, Wien, **1893.**

[110] "Photogrammetrie," Vieweg and Sohn, Braunschweig, **1896.**

[111] "La Photogrammetrie," Gauthier-Villars, Paris, **1908.**

[112] "Applications de la Phot. aux Levés Topographiques," Gauthier-Villars, Paris, **1907.**

[113] "Die Geschichtliche Entwicklung der Photogrammetrie," Strecher und Schröder, Stuttgart, **1913.**

[114] U. S. Geol. Survey, *Bull. No. 657*, **1917.**

[115] Crawford, Ord. Survey Prof. Papers, New Series, No. 7, H. M. Stationery Office, London, **1924.**

[116] "Production of Petroleum in 1924," Am. Inst. Min. and Met. Eng., New York, **1925**, p. 78.

[117] *Ibid.*, p. 82.

[118] *Brit. J. Phot.*, **73**, 27 (1926). See also Winterbotham's chapter in "Photography as a Scientific Implement," Van Nostrand, New York, **1923**, p. 349.

[119] *Sci. Ind. Phot.*, **5**, R., 9 (1925).

[120] "Grundlagen der Photogrammetrie aus Luftfahrzeugen," Wittner, Stuttgart, **1919.**

[121] "Aerial Surveying," Cambridge University Press, **1925.**

sent over the wire. The process is reversed at the receiving end, photographic film being used as the recording medium. Liesegang,[122] Thorne Baker,[123] Ives,[124] and Korn[125] have each published information on this subject. In America, the research has been fostered largely by the American Telephone and Telegraph Corporation.

The transmission of photographs by wireless and radio has been under investigation with a reasonable degree of success as shown by pictures sent across the Atlantic under the auspices of the Radio Corporation of America.[126] Books on the subject have been written by Martin[127] and Jenkins.[128]

Of great value in the field of engineering are photographs recording the progress of construction or destruction of buildings, boats, bridges, etc. The entire construction of the 32-story Strauss Building in Chicago was photographed with a motion-picture camera mounted in a special cage.[129] Highway and marine engineering, railway construction, and salvage operations provide subjects for photography to be examined later by the engineer. Records of changes in arrangement are an important method of examining the rigidity of foundations of large buildings, lumber piles, detection of camouflage and changes in complicated drawings or documents.[130] Two negatives are made of the subject from the same viewpoint at different times, and a positive transparency made from one is superposed on the other which shows the changes as departures from the uniform density of the two plates.

A general discussion of photography applied to engineering and metallurgical industries has been given by Monypenny.[131]

E. Medicine

The most widely used application of photography in medicine is perhaps in connection with X-ray work, though clinical photography is also an important field.[131a] Several instruments have been designed, however,

[122] "Beiträge zum Problem des electrisches Fernsehen," Liesegang, Dusseldorf, 1891.

[123] "Telegraphic Transmission of Photographs," Constable & Co., Ltd., London, 1910.

[124] *Photo. Engravers Bull.*, **15**, 191 (1925); *Trans. Soc. Motion Picture Eng.*, **23**, 82 (1925).

[125] *Camera* (Luzern), **4**, 63, 100, 159 (1925).

[126] "Transmission of Photographs by Radio," R. H. Ranger, *Phot. Engravers Bull.*, 15, 196 (1925).

[127] "Wireless Transmission of Photographs," Wireless Press, Ltd., Glasgow, **1925.**

[128] "Radio Vision," Jenkins Laboratories, Washington, D. C., **1925.**

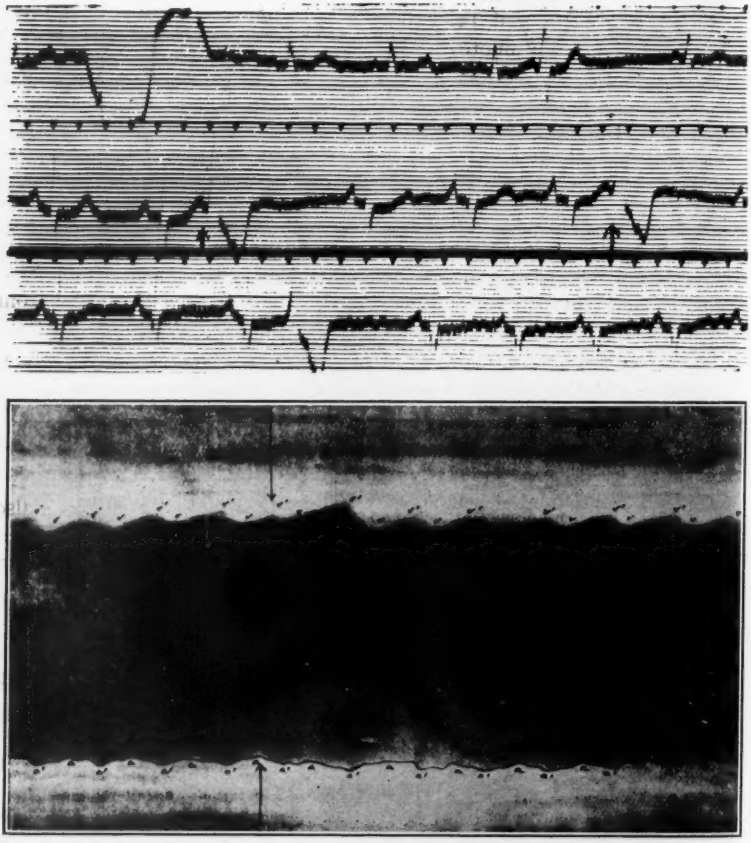
[129] *Visual Educ.*, **4**, 240 (1923).

[130] *Bur. Standards Sci. Paper No. 392*, **1920.**

[131] "Photography as a Scientific Implement," Van Nostrand, New York, **1923**, p. 284.

[131a] "Clinical Photography, Medical Division," Eastman Kodak Co., Rochester, N. Y., **1927.**

which use the photographic emulsion for recording the data. These are the electro-cardiograph, the Röntgeno-cardiograph, and the capillarograph.



Reproduced from Brit. J. Radiology (Röntgen Soc. Section) XXI, 142 (1925). *Paper by R. Knox*

FIG. 10.—Electro-cardiogram and Röntgeno-cardiogram. Upper record shows a positive print of a typical electro-cardiogram with the three different lead records of the shadow of the galvanometer pointer. Lower record is a Röntgeno-cardiogram of the same case, showing undulating movements of the edges of the heart shadow. See reference 135, p. 207.

The electro-cardiograph has been designed for delicate examination of the heart. An impulse is created by the normal heart beat which causes a contraction of the muscle of the ventricle. Preceding the im-

pulse is a very fine electric current which is detected by the instrument and recorded on a moving strip of photographic paper as the shadow band from a galvanometer pointer. The final record is called an electro-cardiogram.[132] (See Fig. 10.)

The second type of instrument, the Röntgeno-cardiograph, was designed under another name by Reider and Rosendahl[133] and improved upon and named as above by Crane[134] and Knox.[135] The patient is arranged before a narrow slit in a lead frame so that the pulsating margin of the heart shadow produced by X-rays is recorded on a photographic film moving transversely past the slit. Several records can be made simultaneously by adjusting two or more slits over different parts of the heart. These records confirm the data recorded by the electro-cardiograph and in addition may be used to estimate the width of the heart, to investigate the movements of the diaphragm, the stomach, and the colon. (See Fig. 10.)

The capillarograph described by Rosenberger[136] enables a kinomicroscopic study to be made of the movements of the skin capillaries. A high intensity arc is required and the light is polarized to avoid partial reflection at the skin surfaces.

5. MISCELLANEOUS APPLICATIONS OF PHOTOGRAPHY

A. Record Keeping and Photo-Reproduction

A valuable application of photography has been its use in the reproduction of printed matter, drawings, blue and brown prints, etc. The record may be either a one-to-one copy, an enlargement, or a reduction positive or negative. The most common method is a straight photographic copy which is usually smaller than the original. There are very few complete reference works on this subject but the two issues of *Photo-Miniature*, Nos. 41 and 56[137] should be consulted. Rose[138] devotes a chapter to the subject, and useful information will be found in a book by Hance.[139] Valuable suggestions on photographing colored subjects

[132] Waller, *Brit. Med. J.*, **2**, 751 (1888). Einthoven, *Arch. ges. Physiol.*, **60**, 101 (1895); *Ibid.*, **99**, 472 (1903); *Ibid.*, **120**, 517 (1908); *Ibid.*, **150**, 275 (1913); *Arch. Intern. Physiol.*, **4**, 132 (1912); *Proc. Roy. Soc. Med.* (*Clinical*), **5**, 183 (1912); "The Mechanism and Graphic Registration of the Heart Beat," Lewis, 2nd edit., London, **1920**. "Diseases of the Heart," Vaquez and Laidlaw, Saunders Co., Philadelphia, Pa., **1924**, p. 126. "Diseases of the Chest," Norris and Landis, 3rd edit., Saunders Co., Philadelphia, Pa., **1924**, p. 198.

[133] *Med. Woch. München*, **1912**.

[134] *Am. J. Röntgenology*, **3** (N. S.) 513 (1916).

[135] *Brit. J. Radiol.* (Roentgen Soc. Section), **21**, 142 (1925).

[136] *Kinotechnik.*, **7**, 585 (1925).

[137] Tenant and Ward, New York, **1905** and **1916**.

[138] "The Commercial Photographer," Chambers Pub. Co., Philadelphia, Pa., **1920**.

[139] "Commercial Photography of To-day," *Abel's Phot. Weekly*, Cleveland, **1914**.

are given in two publications of the Eastman Kodak Company.[140]

If it is desired to reproduce a drawing or another photograph for publication in a journal or a book, special cameras are used which take film, plates, or wet plates. The subject is broken up into tiny dots by placing a transparent cross-line screen in contact with the sensitive medium and exposing through the screen. Though published over thirty years ago, the two pamphlets of Waterhouse[141] still stand as one of the best descriptions of methods of photographing drawings and maps. Hislop[142] has given a useful summary of the subject and the booklet, "Reproduction Work with Dry Plates and Films,"[143] presents complete instructions on exposure and processing. Browne,[144] Hackleman,[145] and H. A. Groesbeck, Jr.,[146] have each published general texts.

H. D'Arcy Power[147] has described experiments in making reduced photographic replicas of important papers, but a more comprehensive article containing additional references has been written by Worischek[148] on photo-bibliographic research. Two types of portable apparatus are described for copying and compilation of reference data.

For rapid recording work, the photostat machine[149] has come to be employed for making a great many types of records. It resembles a studio camera except that there is a reversing prism before the lens and the record is made on a special sensitive paper. There is a self-contained illuminating system and an automatic processing unit arranged so that a dried negative print is obtained in a remarkably short time after making the exposure. If positives are desired, they may be prepared by rephotostating the negative.

The Factograph camera[150] is another rapid recording instrument for meter-reading and making finger print and similar records. The illumi-

[140] "The Photography of Colored Objects," and "Color Films, Plates and Filters for Commercial Photography," Eastman Kodak Co., Rochester, N. Y.

[141] "The Application of Photography in the Reproduction of Maps and Plans," Baptist Mission Press, Calcutta, **1878.** "Practical Notes on the Preparation of Drawings for Photographic Reproduction," Paul, Trench, Trübner & Co., Ltd., London, **1890.**

[142] "Photography as a Scientific Implement," Van Nostrand, New York, **1923,** p. 455.

[143] Eastman Kodak Co., Rochester, N. Y., **1926.**

[144] "Offset Lithography," National Lithographer, New York, **1917.**

[145] "Commercial Engraving and Printing," Com. Engraving Publishing Co., Indianapolis, Ind., **1921.**

[146] "The Process and Practice of Photoengraving," Doubleday, Page & Co., New York, **1924.**

[147] *Camera Craft,* **23,** 223 (1916); **30,** 426 (1923).

[148] *J. Ind. & Eng. Chem.,* **12,** 679 (1920).

[149] *Am. Machinist* (1) **31,** 781 (1908); *Machinery,* **21,** 951 (1915); *Eng. & Contr.,* **46,** 198 (1916).

[150] *Am. Gas & Light J.,* **103,** 141 (1915); *Machinery,* **22,** 75 (1915).

nation is provided in one model by several small battery operated lights held inside a box frame around the lens. Another model is designed so that the lights may be operated from any commercial circuit. On pressing a lever to make the exposure the lamps are lighted for any desired length of time. The record is made on a roll of sensitive paper with a white backing to show up the negative image. Development is conducted in a solution favoring high contrast.

B. Deciphering Charred or Deteriorated Documents

Faded or burned records may sometimes be restored or transcribed as follows: (*a*) By copying a record restored by chemical means; (*b*) by placing the record in contact with a photographic film or plate to allow the emanations from the paper to fog the emulsion selectively; (*c*) by photographing by means of ultra-violet light.

Under (*a*) Michell[151] has found that calcination in stages accompanied with chemical treatment gives most satisfactory results. Method (*b*) incorporates the discovery of Russell[152] that the photographic plate, in the absence of light, is sensitive to the action of certain gases and vapors. Davis[153] has described the use of fast or medium speed plates for recording the details of charred documents by this method; very slow plates and films not being adapted to the work. Using method (*c*) Svedberg and Anderson[154] have shown that a Wratten ultra-violet filter may be employed effectively in conjunction with a quartz mercury lamp to cause the letters of an old parchment document to fluoresce sufficiently for making a satisfactory photographic record. Harrison[155] has recently described the characteristics of photographic materials in the ultra-violet.

C. Photography in the Detection of Crime

For criminal detection photography has been used as follows: (*a*) Finger print analysis; (*b*) identification of forged checks and documents; (*c*) general portraits of criminals; (*d*) records of evidence and measurement and spacing of the location of a crime. Books on the subjects have been published by Bertillon,[156] Urban,[157] and Paul.[158] Both Webb[159] and McGovern[160] have written extensively on the use of the

[151] *The Analyst*, **50**, 174 (1925).
[152] *Brit. J. Phot.*, **44**, 437, 490 (1897).
[153] *Bur. Standards Sci. Paper No. 454*, **18**, 445 (1923).
[154] *Phot. J.*, **47** (N. S.) 30 (1923); also *Phot. Korr.*, **25**, 205 (1915).
[155] *J. Optical Soc. Am.* **11**, 341 (1925).
[156] "Gerichtliche Photographie," Knapp, Halle, **1895.**
[157] "Kompendium Photographie," Nemnich, Leipsig, **1909.**
[158] "Handbuch der kriminalistischen Photographie," Guttentag, Berlin, **1900.**
[159] "Photography as a Scientific Implement," Van Nostrand, New York, **1923**, p. 503.
[160] *Camera Craft*, **30**, 169, 462, 535, 579 (1923); *Ibid.*, **31**, 26, 67, 133, 186, 389, 441 (1924); *Ibid.*, **32**, 31 (1925).

camera in deciphering forged documents. Reiss[161] has published a small volume on analysis of the face as a method of criminal detection.

D. The Use of the Camera for Motion Analysis

For increasing the efficiency of industrial workmen, several types of motion study analyses have been devised which use the photographic films as the recording medium. Thun describes a number of the methods in his book, "Der Film in der Technik."[162] They consist in having the workman wear a very light harness having either tiny electric lights or mirrors to reflect the light from the points to be studied. The results are shown as an illuminated path where the movements are traced.

E. Stoking Register

An automatic record of the time of stoking a furnace is made by an instrument called the Wattles Stoking Register. It consists of a source of light on one side of the chimney and a photographic film or sensitive paper held behind a slit on the opposite side, the smoke cutting off the light in proportion to its volume.

F. Analysis of Guillotine Paper Cutting Knives

By photographing the end of a stack of paper cut by a guillotine knife, the striations resulting from worn places in the knife are clearly shown. The photographs when successively made may be used to study the deterioration of the knife as described by I. C. Matthews.[163]

G. Miscellaneous Uses of X-Rays

Kaye[164] has described many novel applications of X-rays such as testing the quality of golf balls, detecting bubbles in artificial teeth, and revealing changes in paintings.

H. Practical Recommendations

The various types of photographs may be classified as follows: (1) Contact records, whereby an image is produced by contact of the material with the emulsion; (2) ordinary camera photographs; (3) motion pictures; (4) projected images obtained on a band of film or paper which is either stationary or moving on a revolving drum. For manipulative details for securing ordinary camera photographs, elementary works on photography or the voluminous literature supplied by manufacturers should

[161] "Manuel du Portrait Parlé," Roustan, Paris, **1914**. See also section in Vol. IV, p. 37, "Angewante Photographie in Wissenschaft und Technik," Wolf-Czapek.

[162] Verein Deutsche Industrie, Berlin, **1925**, p. 165.

[163] *Paper Trade J.*, **81**, 50 (1925).

[164] *Brit. J. Radiol* (Röntgen Soc. Section), **22**, 67 (1926). See also book by same author, "Practical Applications of X-Rays," Chapman & Hall, London, **1922**.

be consulted. For information regarding the taking of motion pictures the "Cinema Handbook" by A. C. Lescarboura, published by the Scientific American Publishing Company, is recommended. For photography on bands of film or paper it is most convenient to employ motion-picture film or paper of the same width which is readily available.

In choosing between plates and films for photographic purposes the only advantage of plates is the rigidity and flatness although such conditions can be simulated with films by coating a glass plate with ordinary rubber solution or Frisket cement,* allowing this to become tacky and then squeegeeing the film onto this prepared glass surface. The film may be subsequently stripped without any of the rubber solution adhering to it. Films have the advantage that they are non-fragile, the halation is much less than with unbacked glass plates, they can be stored in a minimum space, while owing to the fact that film is manufactured in such large quantities, various batches are more apt to be uniform than in the case of glass plates.

Paper band continuous records are satisfactory if only one record is needed. If it is desired to print a positive record from the negative paper record the transparency of the paper can usually be increased by treating the back of the paper with Russian mineral oil although owing to the graininess of the paper it is not possible to reproduce as fine detail in this way as with film negatives.

In selecting a suitable photographic material, the emulsion having the slowest speed which will satisfactorily perform the work required should be chosen. For line records it might be considered that either a flat or contrasty emulsion would give sufficient density providing the exposure and development were sufficient. A serious difficulty, however, arises when long exposures are given due to irradiation or spreading of light by reflection from the grains of the emulsion[165] and also halation caused by reflection from the back surface of the glass plate or film. This reflection is, however, much less in the case of films than with glass plates. In order to secure fine line records of high density it is, therefore, necessary to use a slow fine-grained emulsion which is capable of giving high densities with a moderate degree of development.

The slower emulsions have the advantage that, owing to their lower sensitiveness, they can be examined more freely in the dark room with a relatively bright safelight, they are capable of rendering finer detail, and they are not so susceptible to chemical fog during development as the

* Obtainable from the Artists' Supply Co., Cleveland, O.

[165] Goldberg, *Phot. J.*, **36** (N. S.) 300 (1912). Nutting, *Ibid.*, **38** (N. S.) 265 (1914). Huse, *J. Optical Soc. Am.*, **1**, 119 (1917). Ross, *Astrophys. J.*, **52**, 201 (1920); *Ibid.*, **53**, 349 (1921).

ultra-high-speed emulsions. High-speed emulsions are, however, imperative for recording short exposures of low intensities.

After exposure, the photographic image is rendered visible by treatment with a chemical solution known as a developer which reduces the exposed grains of the emulsion to metallic silver but leaves the unexposed grains more or less unaffected. The precise effect of light in rendering the silver halide developable is not known although our knowledge of the latent image is progressing rapidly as a result of research.[166]

The rate of growth of the image during development is approximately exponential and increases with time until a limit is reached when development is complete. Certain developers tend to develop more or less of the unexposed grains thus producing chemical fog[167] which has the effect of reducing contrast. In all experimental work where intensities are being investigated, the fog should be measured and subtracted from the normal image value. Fog is not necessarily uniform, however, over the entire image area.[168]

Developers vary in their ability to produce a maximum quantity of developed silver from a given exposure, depending on the nature of the reducing agent and the alkalinity of the developing solution.[169] It is useless, however, to develop beyond the point where the unexposed grains develop as rapidly as the exposed grains, that is, where the rate of growth of fog equals that of image.

The rate of development increases with temperature and in the case of pyrogallol developer the rate approximately doubles for each 15°F. rise in temperature. With rising temperature, there is also greater tendency for the unexposed grains to be reduced, causing fog. When the temperature of the processing solutions is above 75°F., special processing solutions which harden the emulsion and prevent swelling are necessary, owing to the fact that the emulsion normally melts, when wet, at around 95°F.[170]

In the determination of the density of photographic images more or less errors are introduced owing to the inequality of the thickness of the emulsion and to the difficulty of securing uniform development. The uniformity of the coating on film is of a much higher order than on plates, unless plate glass is used. It is very difficult to secure completely uniform development owing to the restraining action of the products of development and to convection currents.[171] Agitation of the developer or of the

[166] Wightman, *Am. Ann. Phot.*, **41**, 37 (1927).

[167] Dundon and Crabtree, *Am. Phot.*, **18**, 742 (1924); *Ibid.*, **19**, 96 (1925).

[168] Wilsey, *Radiology*, **5**, 237 (1925); also *Phot. J.*, **49** (N. S.) 454 (1925).

[169] Crabtree, *Am. Ann. Phot.*, **36**, 184 (1922).

[170] Crabtree, *Trans. Soc. Motion Picture Eng.*, **19**, 39 (1924).

[171] Bullock, *Brit. J. Phot.*, **69**, 110 (1922). Crabtree, *Trans. Soc. Motion Picture Eng.*, **24**, 95 (1926).

film or plate is partially effective,[172] but the most uniform results are secured by developing in a flat tray with the film or plate completely immersed and gently brushing the surface of the emulsion with a wide camel hair brush.

All emulsions should be handled by light to which they are relatively insensitive, otherwise fog will be produced.[167] The choice of a safelight depends upon the sensitivity of both the eye and the emulsion to the light which the safelight transmits. It is possible to examine high-speed emulsions in yellow light which are normally fogged by such a light by treating them before development in a solution of a desensitizer[173] which lowers the sensitiveness of the unexposed emulsion but does not affect the latent image. Panchromatic emulsions are not as responsive to desensitizers as ordinary emulsions but they may be desensitized sufficiently to allow ready inspection during processing. The speed and color sensitivity of panchromatic emulsions may be increased by hypersensitizing with ammonia.[174]

For developing and fixing the manufacturers' instructions should be carefully followed. Full details for the development of motion-picture film have been given by one of the authors.[175]

The illustrations included with the paper have been added to show examples of several kinds of photographic records.

For information relating to several different types of photographic recording apparatus and the loan of photographs, the authors wish to acknowledge their indebtedness to W. R. Amberson, University of Pennsylvania, Philadelphia, Pa.; W. G. France, Ohio State University, Columbus, O.; Dr. John J. Finigan, Genesee Hospital, Rochester, N. Y.; L. M. Griffith, National Advisory Committee of Aeronautics, Langley Field, Hampton, Va.; P. E. Klopsteg, Central Scientific Co., Chicago, Ill.; Anna L. MacLeod, Vassar College, Poughkeepsie, N. Y.; and F. H. Norton, Massachusetts Institute of Technology, Cambridge, Mass.

[172] Sheppard, *et al.*, *J. Frank. Inst.*, **195**, 211 (1923); *Ibid.*, **198**, 333 (1924).

[173] Dundon and Crabtree, *Am. Phot.*, **20**, 378, 438 (1926).

[174] Burka, *J. Frank. Inst.*, **189**, 25 (1920); also "Eastman Panchromatic Negative Film for Motion Pictures," Eastman Kodak Co., Rochester, N. Y., p. 8.

[175] Crabtree, *Trans. Soc. Motion Picture Eng.*, **16**, 163 (1923).

Chromium Used in Auto Manufacture. Chromium, once a chemical curiosity, is now being used in the automotive industry on account of its hardness and resistance to corrosion. W. N. Phillips of the General Motors Corporation reported to the Society of Automotive Engineers meeting in Detroit recently, that chromium plated upon steel and other metals is being used for coating gages, tools, dies and files, finishing radiators, and surfacing bearing surfaces. Chromium has been found to be harder than the hardest steels used in automobile manufacture.—*Science Service*

THE VITAMINS. IV

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The Antirachitic Vitamin, Now Commonly Called Vitamin D

Space does not permit of any attempt to tell here the interesting story of rickets, or even of experimental rickets, as a whole. In order to sketch the present state of knowledge of the antirachitic vitamin in a paper as short as this must be, it will be necessary to omit much which should logically be included regarding other aspects of the rickets problem. Reference may, therefore, be made at the outset to the fact that the general subject of rickets as seen from the viewpoint of the student of chemistry and nutrition has recently been reviewed comprehensively by McCollum and Simmonds[1,*] and briefly by the present writer elsewhere.[2]

Since the essential feature of rickets is a retarded deposition of calcium phosphate in the developing bone, and the immediate or proximate cause of this appears to be a subnormal concentration of calcium or of phosphate ions, or of both, in the blood serum, it is plain that we are here dealing with phenomena belonging quite as much to the field of the mineral elements in nutrition as to the vitamins. Rickets is not so purely a vitamin-deficiency disease as are beriberi and scurvy; and the antirachitic vitamin does not bear the same degree of responsibility for the prevention and cure of rickets as does the antineuritic vitamin in the case of beriberi, or the antiscorbutic vitamin in the case of scurvy. As regards the prevention or occurrence of rickets the scale may be turned either by a difference in the antirachitic vitamin content of the food or by a difference in the amounts and proportions of calcium and phosphorus supplied. The scale may also be turned by sunshine or other suitable irradiation; but this we now believe to be due to the formation of antirachitic vitamin in the body under the influence of ultra-violet rays.

Soon after the discovery of the existence of fat-soluble vitamin (or, as we now know, vitamins), as outlined in the preceding paper of this series, Mellanby pointed out the relation of some such substance or substances to the prevention of rickets, and he has been actively engaged since that time with an extended series of investigations using puppies as experimental animals.

In a series of papers of which the first was published in 1921, Hart, Steenbock, *et al.*, have dealt with dietary factors influencing calcium assimilation, and in 1923 Steenbock changed the general title of his important series of research papers from fat-soluble vitamin to fat-soluble vitamins and in many of the later papers of that series has dealt primarily with the antirachitic factor.

* Numerals refer to bibliography at the end of this paper.

In 1922, McCollum, Simmonds, Becker, and Shipley, of Johns Hopkins University, reported[3] an experimental demonstration of the existence of a vitamin which promotes calcium deposition. They found that when cod-liver oil was heated under oxidizing conditions for 12 to 20 hours the oil lost its antiophthalmic property, indicating that its vitamin A had been destroyed but still had the property of preventing experimental rickets in rats. A convenient method for the production of experimental rickets in rats by means of nutritional deficiency had been published in the previous year[4] as had also the first observations of Hart and Steenbock, indicating the existence of a previously unknown organic substance exerting an important helpful influence upon the assimilation and efficient use of calcium in the animal body. These first observations of the Wisconsin investigators had been made upon farm animals with which, as with the puppies used by Mellanby, growth, development, and the completion of the life cycle are relatively slow. From 1922 onward, with the rat (which lives its life from 30 to 40 times as fast as does the human), established as the chief experimental animal and with the great interest in rickets which has been manifested by the medical profession and by the public as well as by nutrition workers, progress in the study of experimental rickets and of the antirachitic vitamin has been exceedingly rapid.

Zucker, of the Department of Pathology, Columbia University,[5] showed that the antirachitic vitamin of cod-liver oil is one of the substances which constitute its unsaponifiable matter but is apparently not identical with any of the previously known substances of this group.

Steenbock and Nelson[6] showed that the antirachitic factor is also a factor in growth. At first this seemed to run counter to the clinical evidence that rickets is more noticeable in growing than in non-growing infants; but it is now seen that there is no real inconsistency.

Whether the shortage of the antirachitic vitamin was manifested by retardation of growth or by X-ray or other evidence of the presence of rachitic bone, ultra-violet irradiation was found to be interchangeable with cod-liver oil in supplying the need and, furthermore, both of these antirachitic agents were found to have the effect of "mobilizing" the calcium and phosphorus resources of the body so that, under either treatment, the concentration of calcium and phosphate ions in the blood serum tends to return to normal.

In 1924, Hess, working in the Department of Pathology of Columbia University, and Steenbock, in the Department of Agricultural Chemistry of the University of Wisconsin, independently and simultaneously discovered that antirachitic properties could be imparted to certain foods and tissues by subjecting them to ultra-violet irradiation; and both demonstrated shortly thereafter that the definite substance, cholesterol, which is well known as a constituent of the animal, and the related plant

sterol, generally called phytosterol, have the property of becoming antirachitic, or of being changed into an antirachitic substance or substances under such irradiation. Assuming for convenience, what seems in all probability true, that the antirachitic substance thus formed from pure cholesterol is the same as the naturally occurring antirachitic substance of cod-liver oil, egg yolk, milk, and butter (vitamin D), we have, in this discovery, the first recorded instance of the production of a vitamin *in vitro*. We have also here the evidence of a very close relationship between vitamin D and a well-known substance which has long been familiar as a recognized chemical individual, although the details of its complete chemical structure may or may not be regarded as entirely certain. Naturally, great interest attaches to the problem of the nature of the chemical change which the ultra-violet light produces in the cholesterol or other sterol and which thus gives rise to the formation of the antirachitic substance (presumably vitamin D). The absorption spectrum appears to be altered and the antirachitic substance seems not to be precipitated by digitonin as is the original sterol; but this latter observation must be interpreted with caution for the actual amount of antirachitic substance present at any one time may be very small. Both Steenbock and Hess found that prolonged irradiation causes first a gradual formation and then a gradual destruction or inactivation of the antirachitic substance.

Hess and Weinstock[8] found that "activated cholesterol" absorbs ultraviolet radiation to a less degree than does cholesterol, and that this difference can be seen to develop progressively with the irradiation until the irradiation has been continued too long, when (along with the decrease of antirachitic activity) the product becomes less transparent than even the original cholesterol. This comparatively opaque product is of a yellowish color and has a lowered melting point. Visible light, radiant heat, and X-rays do not thus alter the absorption spectrum of cholesterol. Furthermore, neither dihydrocholesterol nor dihydrophytosterol undergoes a similar change as the result of irradiation. Hence the chemical changes noted appear to be connected with the change of cholesterol into vitamin D and of this into an unidentified substance not antirachitically active.

Moreover, Hess and Sherman[9] found that irradiation of cholesterol changed its property of inhibiting the hemolytic action of digitonin, and here also the effect induced by irradiation was later lost if irradiation was continued too long.

Hess, Weinstock, and Sherman[10] estimate the proportion of cholesterol rendered non-precipitable by digitonin, presumably through conversion into the antirachitic substance, as 4.5 per cent after two hours, or 9 per cent after six hours, irradiation.

Bills[11] has investigated the effects of various reagents upon the antirachitic properties of cod-liver oil and of irradiated cholesterol.

In view of all the evidence it seems probable that the vitamin D activity is a property of some substance intermediate between cholesterol or phytosterol on the one side and on the other side another physiologically inactive substance not yet chemically identified. So far as we know these three substances representing the original sterol and the two stages of transformation induced by ultra-violet light may all be very closely related to each other chemically.

Naturally, the intense interest attaching to the rapid strides of recent years in the problem of the cause, prevention, and cure of rickets; to the discovery that foods and tissues and the individual substance cholesterol can be made antirachitic by irradiation so that it becomes probable that irradiation actually produces vitamin D in the body from the cholesterol always present in the skin; and to the search for the chemical explanation of the formation of the antirachitic substance as well as for its chemical identity, have tended to absorb attention to such an extent as to delay the working out of quantitative methods by which the distribution of vitamin D in nature and in our ordinary foods can be studied with the same definiteness and approach to precision as is now possible in the case of vitamin A, or B, or C. In fact the dietary deficiencies commonly and conveniently employed to induce rickets experimentally in rats have generally been so drastic that a relatively considerable amount of vitamin D would seem to be necessary to effect a satisfactory prevention or cure so that moderate vitamin D values in foods or tissues tested might not be demonstrated and therefore a negative result be erroneously reported. In this respect Mellanby's work with puppies may have been more delicate than most of the work heretofore carried out in this country with rats, for Mellanby very plainly demonstrates what some other investigators have appeared to doubt, namely, that leafy garden vegetables, whole milk, and butter are important sources of vitamin D. Egg yolk had already been shown to be an important source, by Hess. The great richness of cod-liver oil in this vitamin should be, as it is, highly appreciated; but it is to be hoped that methods may soon be developed to permit of the measurement of the smaller but still significant concentrations found in various plant and animal tissues as they occur in nature and as they are used as food, not only by infants but also by adults, for even in 1924 the Wisconsin investigators explicitly stated[7] that ultra-violet light (and hence we should now believe, vitamin D) "can influence the storage of calcium and phosphorus and the equilibrium of these elements in the blood stream of mature animals in a way similar to its effects upon growing animals." Presumably vitamin D is a significant factor in nutrition at all ages.

Then, too, in order to extend our acquaintance with vitamin D we should be able to determine its occurrence and relative concentrations

in plant and animal tissues even when these contain only small amounts. At present we can say little more in this connection than that vitamin D appears to be formed in both plants and animals under the influence of direct sunlight or any other form of irradiation which supplies ultraviolet rays; that the blood carries to the interior of the body the vitamin which has been formed in the skin; that somewhere in the body (probably largely in the liver) vitamin D can, like vitamin A, be stored to a relatively large extent; and that through the milk or the egg, as the case may be, the maternal organism provides vitamin D for her offspring in forms which are well suited for human consumption and utilization.

Hess[12] has recently shown that the antirachitic value of human milk can be markedly increased by the irradiation of the mother. Undoubtedly the same physical, chemical, and physiological relationships hold good in the case of cow's milk but the effective irradiation of the cow may, perhaps, present greater difficulties because of her size of body, thickness of skin, and coat of hair. That cow's milk itself can be irradiated with resulting enrichment of its vitamin D content has been repeatedly demonstrated in different laboratories. A further means of augmenting the vitamin D value of milk is, of course, the feeding of food rich in vitamin D, such as cod-liver and other fish-liver oils, to the milk cows. This is not only practicable but also, as pointed out both by Drummond, Zilva, and Golding in England and by Hart and Steenbock[13] of Wisconsin, it may very probably prove to be economically profitable to the dairy farmer, particularly as consumers come to understand and appreciate more fully the vitamin values of their foods.

References

NOTE: Since the first and second publications of the present list may be consulted for bibliographies, the present list is confined to those few references which are made necessary by actual citation in the foregoing text.

[1] E. V. McCollum and N. Simmonds, "The Newer Knowledge of Nutrition," third edition, The Macmillan Company, New York, **1925.** See especially Chapters XIX, XX, and XXI and bibliography at the end of the book.

[2] H. C. Sherman, "Chemistry of Food and Nutrition," third edition, The Macmillan Company, New York, **1926.** See especially Chapter XVII and the bibliography at the end of that Chapter.

[3] E. V. McCollum, N. Simmonds, J. E. Becker, and P. G. Shipley, *J. Biol. Chem.*, **54,** 249 (1922).

[4] H. C. Sherman and A. M. Pappenheimer, *Proc. Soc. Exptl. Biol. Med.*, March, **1921,** and *J. Exptl. Med.*, **34,** 189 (1921).

[5] T. F. Zucker, *Proc. Soc. Exptl. Biol. Med.*, **20,** 136 (1922).

[6] H. Steenbock and E. M. Nelson, *J. Biol. Chem.*, **56,** 355 (1923).

[7] E. B. Hart, H. Steenbock, and C. A. Elvehjem, *Ibid.*, **62,** 117 (1924).

[8] A. F. Hess and M. Weinstock, *Ibid.*, **64,** 193 (1925).

[9] A. F. Hess and E. Sherman, *Proc. Soc. Exptl. Biol. Med.*, **22**, 169 (1925).

[10] A. F. Hess, M. Weinstock, and E. Sherman, *J. Biol. Chem.*, **67**, 413 (1926).

[11] C. E. Bills, *Ibid.*, **64**, 1; **66**, 451 (1925); **67**, 753 (1926).

[12] A. F. Hess, M. Weinstock, and E. Sherman, *J. Am. Med. Assoc.*, **88**, 24 (1927).

[13] E. B. Hart, H. Steenbock, C. A. Elvehjem, H. Scott, and G. C. Humphrey, *J. Biol. Chem.*, **67**, 371 (1926).

Corn Borer Follows Scent Trail to Plant. "Follow your nose" seems to be the maxim observed by the corn borer moth when she seeks appropriate food plants on which to deposit her eggs. This dangerous crop pest, which threatens to do for corn what the weevil has done for cotton, has been the subject of study by numerous scientists during the past summer, and a report, as yet unpublished, indicates that the night-flying insect finds her way through the dark to her destination because the victim-plant secretes an odorous substance attractive to her.

The group of workers who found this indication of the lure of the corn for the corn borer state that they made distillates from the leaves and stalks of corn which they found heavily infested, as well as from plants comparatively free from the pests, and then tried this material on captive moths. They found in general that the insects were strongly attracted to the distillates from the infested plants, especially those made from the younger leaves, and that they did not respond so readily to the distillates from the borer-free stalks.

The distillates are clear and colorless liquids and, even to the comparatively dull nostrils of human beings, have a noticeable scent. This must strike the keen odor-sense of the insects as powerfully as the waving of a red flag does the human eye.

These experiments are part of a research program aiming to breed a variety of corn that will be resistant to the attacks of the corn borer.—*Science Service*

"Death Whisper" Waves Produced by Crystals. The effects of the new "death whisper" investigated by Prof. R. W. Wood, of the Johns Hopkins University, and A. L. Loomis, in the latter's private laboratory at Tuxedo Park, N. Y., were described before the meeting of the American Association for the Advancement of Science by Dr. Frank Thone of *Science Service*, Washington, D. C.

The "death whisper," Dr. Thone stated, is simply a nickname for vibrations similar to those of ordinary sound, but produced so rapidly that the human ear cannot hear them, just as the human eye cannot see ultra-violet light or X-rays. They are generated by means of electrically excited quartz crystals in a bath of oil. When a vessel of water containing a small fish or tadpole or other aquatic animal, or some kinds of water plants, is set on top of the vibrating crystal the waves are shot through the glass into the water, and there they kill the animal or plant, and frequently break down its structure so completely that it simply disappears.

While the waves cannot leave the liquid, Dr. Thone explained, they will pass through solids and will penetrate human flesh and bone, causing pain at high intensities, but giving rise to no sensation but a feeling of warmth at low ones. At the lower intensities, however, they are still destructive to the red cells of the blood, and a mouse was once kept exposed to them until it had a bad case of artificial anemia without showing the least sign of discomfort.

The discovery of the possible uses of these inaudible sound waves was made by Prof. Wood during the War, as a result of a chance observation in the laboratory of Prof. P. Langevin at the great naval arsenal at Toulon, where the French scientist was experimenting with them in an endeavor to perfect an apparatus for the detection of submarines.—*Science Service*

THE STRUCTURE OF MATTER: A BRIEF REVIEW OF PRESENT-DAY CONCEPTIONS

V. UP-TO-DATE CHEMISTRY IN THE GENERAL CHEMISTRY COURSE

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How Much?

Opinions will, of course, differ very widely as to how much of the material outlined in the preceding papers of this series should be taught in a general chemistry course in high school or college, also as to how and when it should be taught. All the writer can do is to give his own ideas about these matters, offering them as suggestions to others having this problem to face.

The importance of a knowledge of this material—because of its value in systematizing and explaining old facts and in predicting new facts and suggesting new experiments—cannot be questioned, especially as much of the chemistry of the future—for which we should prepare our students—is sure to be intimately connected with these developments of the past few years. Most important of all, perhaps, is the interest-arousing power of the subjects. The student is sure to be more interested in chemistry if he can see just what advances chemists have made in the past few years toward answering his "what" and "why" questions and if he is given hints now and then as to problems still awaiting solution than if he is taught chemistry as though it were a dead language.

For such reasons, the writer believes in including a large percentage of the subject-matter dealt with in these papers in a course in general chemistry—especially in a college course.

What?

In a *high-school* course, it would seem to be important to define and explain rather carefully such terms as proton, electron, nucleus, element, isotope, kernel, valence electron, atom, ion, molecule, and polarity. The relationships between these entities and a simplified periodic table should be discussed. The tendencies of valence electrons to form pairs and octets and the methods by which these tendencies are satisfied should be emphasized—the student should have as clear an idea as possible of the nature of chemical combination.

The Bohr theory should be mentioned, for the student should realize that the electrons are probably not in fixed positions, although for chemical purposes we treat them as if they were.

The regularity characteristic of crystals and the irregularity characteristic of amorphous solids and liquids should be pointed out. Simple

crystal structures, such as those of C, ZnS, NaCl, CaF_2, As, HgI_2, Se, SnI_4, and the "close-packed" metals might profitably be described and explained in terms of the structures of the component atoms.

When organic chemistry is under discussion, the nature of double and triple bonds should, of course, be mentioned.

In a *college* course the same ground ought to be covered, but in more detail, especially the consideration of the relationships between the periodic system and structure and the study of crystal structures. All of the type structures mentioned in the fourth article of this series might well be taken up.

Secondary valence should be considered in some detail and residual affinity mentioned.

The simple Bohr theory might be discussed, but it should not be emphasized.

When?

The writer believes that the sooner the fundamental ideas of atomic and molecular structure are introduced to the student the better. He should be taught early to think in terms of atoms, molecules, and electrons and to relate likenesses in properties to structural similarities and to periodic system relationships. These relationships should be stressed throughout the course; they serve to correlate and explain a large number of otherwise unrelated and unaccounted for facts.

The study of crystal structures can conveniently be introduced when the nature of solids is first taken up. Particular structures can be considered later as various elements and compounds are mentioned.

A discussion of secondary valence would seem to be most appropriate in connection with the study of complex ions.

The new material should not, in the writer's opinion, be taught as a separate subject, but should be impregnated into the course in such a way as to make the point of view throughout an up-to-date one.

How?

It is up to each individual teacher to determine just how to revise his course so as to include this new material. Methods must vary with the teacher, the text-book, and the available equipment. The author recommends the liberal use of models, diagrams, and problems. A set of model-building apparatus should prove very useful, both for lectures and in the laboratory.[1]

[1] The writer has found one-inch cubes of maple, having $^1/_8$" holes bored in each corner and the center of each face and used with $^1/_8$" aluminum rod cut to appropriate lengths, very satisfactory. Solid rubber balls, one inch in diameter, which can be bought for a cent apiece, are also very useful. Holes can be made in them very easily by means of a hot awl or nail.

The teacher should, throughout the course, instill interest by reference to unsolved problems and unproved theories, but in so doing he should religiously differentiate between fact, theory, and speculation, and try to train his students to do the same.

Old Shale Oil Industry to Rival Coal in Importance. The distillation of shale, which promises to become very important to the entire nation, is not a new way of getting oil at this time of approaching scarcity, but is merely an old method brushing its cobwebs off after over half a century of disuse in the United States. In France it is older yet, for there the production of oil from shale started in 1838, according to Dr. G. C. Riddell, consulting engineer of New York. In Scotland, oil was obtained from shale before 1850, but the best of the raw material is today exhausted. Shale pits 3000 feet deep show how the industry once flourished.

In 1850 oil was distilled from shale in Utah and Pennsylvania, and the development of a great shale industry would have resulted but for the discovery of well oil. The "liquid gold" fever following the development of oil in drilled wells in Pennsylvania caused the interest in shale oil to dwindle and then die, just as an impending scarcity has brought it to life again.

To date 186 patents have been granted in the United States for the production of oil from shale. Five of these were granted in 1858, fifteen in the next six years, and none at all after that until 1891. From 1891 to 1914 ten patents were granted, from 1915 to 1919, thirty-four, and from then to the present time one hundred and seven.

The competitive production of oil by distilling bituminous rocks is no longer in doubt, Dr. Riddell states, for in California it has been produced for three years at less than one dollar a barrel including all overhead charges. This is far below the average cost of American well oil.

The question as to what is to become of the vast amount of spent shale that will result with the development of the industry is puzzling many theorists. The by-product can be used for making pressed, refractory, and insulating brick and tile, Dr. Riddell says, and at present it has found lesser uses as road material, concrete building blocks, and as a filtering substance in the sugar industry.

That the new shale industry is destined to become as great as the coal industry is now, is recognized by engineers and geologists generally. The new business will be developed in the now sparsely populated regions, Dr. Riddell points out, and town roads, water systems, movies, and other kinds of civilization will appear there.—*Science Service*

Plants Do Not Need Vitamins for Growth. For about fourteen years it has been known that animals require in their diet organic substances of unknown composition, termed vitamins, before health can be kept up or growth obtained. These vitamins occur in plants such as spinach, cabbage, and tomatoes. Dr. Norman Clark of Iowa State College has investigated the possibility that green plants, in their turn, require similar organic substances in order that they may thrive. He stated that organic matter is not needed, in his report before the Botanical Society of America, recently.

Small green duckweeds, familiar objects on the surface of ponds throughout the country, were grown by the use of carefully purified chemicals. It was found, when conditions were made favorable, that the plants were perfectly healthy, and reproduced without the addition of any substance of unknown composition. Dr. Clark states that these results indicate there is no vitamin-like substance essential for the growth of all green plants. There is still the possibility that organic matter may stimulate or increase the growth in plants, but it is not an essential in the same way as vitamins are essentials in the food of animals.—*Science Service*

THE POLE REACTION METHOD OF TEACHING OXIDATION AND REDUCTION REACTIONS[1]

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In 1910 Professor E. P. Schoch, at the University of Texas, began teaching oxidation and reduction reactions as electron exchange reactions. From the first the method has been in use in classes of first-year college chemistry. Both Professor Schoch and his successors made many changes in detail in the method since 1910 but the fundamental ideas have not been changed. A somewhat similar method has been in use at the University of California for a number of years and, recently, Brinkley[2] described a similar method developed at Yale.

The teaching of oxidation and reduction reactions is prefaced by a series of lectures on the periodic system as developed and, especially, as explained by means of modern theories of atomic structure. Only generally accepted ideas of structure are presented, but there is enough agreement in these to permit the use of atomic structure lectures as a valuable introduction to electron exchange reactions of all kinds. This topic is followed by a chapter on electrolysis which naturally leads to consideration of back electromotive force of electrolytic cells or to the electromotive force of battery cells. Although both electrolytic and battery action are oxidation and reduction reactions, oxidation and reduction reactions, as commonly discussed, result only when the constituents of the two battery poles are mixed. Even in the case of electrolytic reactions the equations for all pole reactions are written as encountered, and balanced so as to make the number of electrons lost equal to those gained.

The first step in the study of oxidation and reduction reactions involves predicting whether a reaction will take place and knowing what products will result. From data derived during demonstration, a simple electromotive force table is drawn up and explained before the fairly complete e. m. f. table is presented (Table I).[3] The student is expected to become thoroughly familiar with this table without actually memorizing it. Each line represents a complete reversible pole or half cell, *i. e.*, the combination may be used as pole of either an electrolytic or battery cell. The left-hand member of each pole has the greater; the right-hand member the lesser number of electrons, so that in changing from the condition on the left to that on the right-hand side the atom or ion loses one or more

[1] Paper read before the Division of Chemical Education, American Chemical Society, Tulsa, Okla., April 7, 1926.

[2] S. R. Brinkley, THIS JOURNAL, 2, 576 (July, 1925).

[3] For the original table see Liddell, "Handbook of Chemical Engineering," McGraw-Hill Book Co., 1922, vol. II, p. 690.

electrons. The strongest reducing agents then are found in the upper left-hand corner; the strongest oxidizing agents in the lower right-hand corner of the table. Whenever the left-hand member of one pole is electrically connected to or mixed with the right-hand member of any pole below it in the table, a battery or oxidation and reduction reaction takes place. If the ions or atoms are both right-hand or left-hand members there can be no electron exchange; if they are so situated that counter clockwise rotation would result, only electrolytic and no battery action can take place. Any electron exchange in this case would have to proceed with

TABLE I

ELECTROMOTIVE FORCE TABLE

	Elements in reduced state	Relative changing tendency in volts	Elements in oxidized state
1	Potassium metal	−5.00	K^+ salt sol. + 1 (−)
2	Sodium metal	−4.80	Na^+ salt sol. + 1 (−)
3	Calcium metal	−4.50	Ca^{++} salt sol. + 2 (−)
4	Magnesium metal	−3.50	Mg^{++} salt sol. + 2 (−)
5	Aluminum metal	−3.00	Al^{+++} salt sol. + 3 (−)
6	Hydrogen gas	−2.80	H^+ ions in *N*/1 NaOH sol. + 1 (−)
7	Zinc metal	−2.76	Zn^{++} salt sol. + 2 (−)
8	Sulfide ion (sodium sulfide sol. normal in S^{--})	−2.55	S° element + 2 (−)
9	Iron metal	−2.43	Fe^{++} salt sol. + 2 (−)
10	H_2 (1 atm.)	2.414	H^+ ion (neutral water)
11	Cadmium metal	−2.40	Cd^{++} salt sol. + 2 (−)
12	Sulfide ion (sat. sol. of hydrogen sulfide in pure water)	−2.35	S° element + 2 (−)
13	Lead metal	−2.34	Pb^{++} in (sat. sol. of $PbSO_4$) + 2 (−)
14	Nickel metal	−2.17	Ni^{++} salt sol. + 2 (−)
15	Sulfide ion (sat. sol. of H_2S in normal HCl)	−2.15	S° element + 2 (−)
16	Lead metal	−2.12	*N*/1 Pb^{++} salt sol. + 2 (−)
17	Tin metal	−2.10	Sn^{++} salt sol. + 2 (−)
18	Hydrogen gas	−2.0	*N*/1 H^+ ion sol. + 1 (−)
19	Bismuth metal (same for Sb)	−1.8 (?)	Bi^{+++} salt sol. + 3 (−)
20	Stannous ion (stannous chloride sol)	−1.76	Sn^{++++} salt sol. + 2 (−) (stannic chloride sol.)
21	Mercury metal	−1.70	Hg^+ salt sol. + 1 (−) (Hg_2Cl_2 in normal Cl^- sol.)
22	Copper metal	−1.66	Cu^{++} salt sol. + 2 (−)
23	Iodide ion (normal in I^-)	−1.46	I° element + 1 (−) (sat. sol. of iodine)
24	Ferrous ion (sol. normal in Fe^{++})	−1.25	Fe^{+++} salt sol. + 1 (−) (normal in Fe^{+++})
25	Silver metal	−1.20	Ag^+ salt sol. + 1 (−)
26	Mercury metal	−1.14	Hg^+ salt sol. + 1 (−)
27	Oxygen ion (in neutral sol.)	−1.18	Oxygen gas (sat. sol.) + 2 (−)
28	Bromide ion (sol. normal in Br^-)	−0.92	Br° element (sat. sol.) + 1 (−)

TABLE I (*Concluded*)

ELECTROMOTIVE FORCE TABLE

	Elements in reduced state	Relative changing tendency in volts	Elements in oxidized state
29	Sulfur in compounds, with valence less than 6 (+)	−0.80 (?)	S^{6+} compounds + free (−) (conc. H_2SO_4)
30	Nitrogen in compounds, with valence less than 5 (+)	−1.00 to −0.72	N^{5+} compounds (HNO_3) + free (−)
31	Cr^{+++} compounds	−0.7	Cr^{6+} compounds + free (−) (sol. of chromic acid)
32	Chloride ion (sol. normal in Cl^-)	−0.65	Cl° element (sat. sol.) + 1 (−)
33	Mn^{++} compounds	−0.49	Mn^{7+} compounds + 5 (−) (sol. of permanganate)
34	Cl° element	−0.40 (?)	Chlorine in compounds where it has positive valence + free (−) (NaOCl, $KClO_3$)
35	Oxygen ions (in any acid sol. having very few O^{--} ions)	−0.30 (?)	Oxygen gas liberated from a platinum pole by electrolysis of salts of oxy-acids such as nitrates, sulfates, phosphates + free (−)
36	Pb^{++} ion (in sat. sol. of $PbSO_4$ in dil H_2SO_4)	−0.34	Pb^{4+} (from PbO_2—solid in dil. H_2SO_4) + free (−)
37	Fluoride ion sol.	−0.10	F° element + 1 (−)
38	Theoretical zero pole	0.00	Theoretical zero pole

Solutions are normal unless stated otherwise.

energy supplied from without. A number of atom-ion combinations are listed in several positions in the table to show the effect of concentration of the ion concerned and the subject of this type of shift in position is stressed during the last few lectures on electron exchange reactions when reactions of nitric and sulfuric acid are considered in detail. The subject of corrosion of iron brings out other cases of such a shift of voltage.

Familiarity with the periodic and electromotive force tables enables the student to predict when an electron exchange reaction should take place and what products will be formed. Even when he encounters border line cases he can make an intelligent guess as to the products probably formed.

As chemical equations form a very valuable means of concise and accurate expression, a simple, consistent, and logical method of deriving the complex forms sometimes met in oxidation and reduction reactions is highly important and, from the standpoint of the teacher, very desirable. Here, again, the electron is treated as an entity or unit of matter which is as much a part of the oxidation and reduction reaction as the ion is of the metathetical reaction.

Even though the student is not expected, in later years, to derive equa-

tions by the following method when he can write them by inspection, the beginning student is required to derive every oxidation and reduction equation used regardless of degree of simplicity. This requirement is insisted upon to make the student thoroughly familiar with the mechanical steps involved before the more difficult equations are encountered in his work. The steps required are:

(1) Writing of the negative pole equation,
(2) Writing of the positive pole equation,
(3) Balancing of above and adding,
(4) Adding to both sides of all ions accompanying any ions of step (1) or (2) and of any salifying acid required.
(5) Combining of (3) and (4) to form the final complete equation.

The following sample derivations illustrate the use of the 5 steps of the derivation:

1. Equation for reaction between metallic zinc and hydrochloric acid.

$$\begin{aligned}
&(1)\ Zn^{\circ} - 2(-) \rightleftharpoons Zn^{++}\\
&(2)\ 2H^{+} + 2(-) \rightleftharpoons H^{\circ}_{2}\\
&\hline
&(3)\ Zn^{\circ} + 2H^{+} \rightleftharpoons Zn^{++} + H^{\circ}_{2}\\
&(4)\ 2Cl^{-} = 2Cl^{-}\\
&\hline
&(5)\ Zn^{\circ} + 2HCl \rightleftharpoons ZnCl_{2} + H^{\circ}_{2}
\end{aligned}$$

2. Equation for reaction between $KMnO_4$ with $FeSO_4$ in H_2SO_4 solution.

$$\begin{aligned}
&(1)\ 10Fe^{++} - 10(-) \rightleftharpoons 10Fe^{+++}\\
&(2)\ 2Mn^{7+} + 10(-) \rightleftharpoons 2Mn^{++}\\
&\hline
&(3)\ 10Fe^{++} + 2Mn^{7+} \rightleftharpoons 10Fe^{+++} + 2Mn^{++}\\
&(4)\ 10SO_4^{--} + 2K^{+} + 8O^{--} = 10SO_4^{--} + 2K^{+} + 8O^{--}\\
&\quad 8SO_4^{--} + 16H^{+} = 8SO_4^{--} + 16H^{+}\\
&\hline
&(5)\ 10FeSO_4 + 2KMnO_4 + 8H_2SO_4 \rightleftharpoons 5Fe_2(SO_4)_3 + 2MnSO_4 + H_2SO_4
\end{aligned}$$

3. Equation for reaction between aluminum metal and sodium nitrate with excess sodium hydroxide.

$$\begin{aligned}
&(1)\ 8Al^{\circ} - 8 \times 3(-) \rightleftharpoons 8Al^{+++}\\
&(2)\ 3N^{5+} + 3 \times 8(-) \rightleftharpoons 3N^{3-}\\
&\hline
&(3)\ 8Al^{\circ} + 3N^{5+} \rightleftharpoons 8Al^{3+} + 3N^{3-}\\
&\quad 3Na^{+} + 9O^{--} = 3Na^{+} + 9O^{--}\\
&\quad 5Na^{+} + 5O^{--} + 5H^{+} = 5Na^{+} + 5O^{--} + 5H^{+}\\
&\quad 4H^{+} + 2O^{--} = 4H^{+} + 2O^{--}\\
&\hline
&(5)\ 8Al^{\circ} + 3NaNO_3 + 5NaOH + 2H_2O \longrightarrow 8NaAlO_2 + 3NH_3
\end{aligned}$$

This scheme of deriving the final equation by simple and fundamental steps seems, at first hand, to require too much time and energy, but is well worthwhile as it eliminates all memorizing of complete equations or even of key equations for each oxidizing agent and it enables the student to derive the equation for any reaction with which he is sufficiently familiar to predict the probable products formed in the first two steps.

Long experience with the method leads us to believe this method is the most satisfactory one in use not only as far as immediate results are concerned, but also because it is based on fundamental principles that are constantly used in advanced work.

Heart Extract Makes Dead Hearts Beat. A "heart hormone," a physiologically powerful chemical compound secreted within the living heart and acting to keep it beating ceaselessly, has been discovered by Dr. Ludwig Haberlandt of the University of Innsbruck. It is to be classed with the secretions of the ductless glands, such as the thyroid in the throat and the adrenals near the kidneys, which have far-reaching effects in the lives of men and animals, and some of which are now widely used in medicine.

Prof. Haberlandt states that the existence of some such internal chemical stimulus to action had long been suspected, because frequently hearts removed from the bodies of animals kept on beating outside, which they would not have done had the stimulus been supplied by the nervous system alone. He found that extracts from a portion of the heart of the frog would act on the stilled heart removed from another frog, causing it to contract again. The extract was able to cause this reaction even in hearts that had been lying still in glass dishes for as much as three and one-half days.

A similar extract from the hearts of dogs, having comparable effects, has been obtained in Brussels by Dr. J. Demoor, and is cited by Prof. Haberlandt as proof that this "heart hormone," as he has named the compound, is of general occurrence among vertebrates and of physiological importance to warm-blooded animals.

The Austrian physiologist is of the opinion that his newly discovered hormone may come to have considerable importance in medicine, as a stimulant to weak hearts. He points out that an abundant supply is easily available in the hearts of animals killed for meat in the packing houses.—*Science Service*

Parents' and Friends' Ratings Little Use in Judging Students. The ratings given by parents and friends are of little use in judging the ability of students to do college work, said Dr. E. L. Clark, director of admissions at Northwestern University, who described to the American Association for the Advancement of Science, in session in Philadelphia recently, what information has been of value and what has not, concerning students whose ability to do college work is doubted.

The filling out of information blanks by parents or friends has proved to be of little value in determining whether these students would be able to keep up to college standards if admitted, he said. Neither does the age of a student at entrance nor the nationality of his parents have much relationship to grades, he stated. Of more value is information concerning failures the student may have made in high school, especially in courses required of college freshmen, though standing in the smaller schools is not so much to be depended upon as standing in the larger schools. Information concerning the number of high schools attended is also of value. Students who have been to three or four high schools nearly always do poorer work than might otherwise be expected, Dr. Clark said.—*Science Service*

THE ELECTROMOTIVE SERIES AND THE PERIODIC TABLE

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Modern text-books of first-year chemistry do not emphasize an interesting relationship that exists between the electromotive series and the periodic table. In fact one of the most widely used texts in first-year college chemistry lists among the defects of the periodic system the absence of any relationship between these two important generalizations of the science. It is true the relation that may be derived from the order in which the elements stand in the two tables is limited, but it is sufficient to furnish a striking example of how our modern conceptions of the structure of atoms enable us to obtain a clearer insight into the mechanism of chemical reactions. In following our present-day practice of placing emphasis upon interpretations based on atomic structure the author has found this illustration very enlightening to students of first-year chemistry.

Reference to a periodic table and to a table of the order of activity of the metals will show that in the alkali family the heaviest metal is the most active, the next heaviest is second in order of activity, and that this relation holds throughout this family. Immediately below lithium, the lightest and least active metal of the alkalies, we find in the electromotive series the following for the order of decreasing activity of the alkaline earth family: barium, strontium, calcium, and magnesium; turning to the periodic table we find this to be the same as the order of decreasing atomic weights. There is no such well-defined relation between the order of activity and the atomic weights of the other metals in the electromotive series, but turning to the most characteristic family of non-metals we find that the order in which the halogens stand in the family is the same order in which they stand in the electromotive series, the lightest being the most active.

A rational explanation for this relationship may be found in recent developments of Bohr's theory of atomic constitution.[1] If metals are defined as elements whose atoms react by loss of valence electrons, then the most active element is the one that loses its valence electrons most readily. According to the electromotive series cesium should lose its one valence electron more easily than any of the other alkali metals; according to the postulates of Bohr's theory it does so because the highly elliptical (6_1) orbit of its valence electron is pushed so far from the nucleus by the fifty-four other planetary electrons of the atom that the attractive forces between the nucleus and the valence electron are more weakened than is the case with any other members of

[1] Niels Bohr, "The Theory of Spectra and Atomic Constitution," Cambridge University Press, London, 1922, p. 61.

the family. The (2_1) orbit of the valence electron of lithium is nearer to the nucleus than the orbits of the valence electrons of the other members of the alkali metals, and as a result the attractive force is greatest and the electron is most firmly held. A similar line of reasoning is employed to interpret the order of activity of the alkaline earth metals. In the halogen family the most active member is that one which most readily gains electrons, since non-metals react by gaining electrons; from Bohr's theory we should expect fluorine to be the most active, because the circular (2_2) orbits of its valence electrons are nearest the nucleus where the attractive forces are strongest.

From this simple observation of the relation of atomic weights and the order of activity in the most characteristic families of the metals and non-metals, we are able to present to the student strong arguments for the necessity of obtaining a knowledge of atomic structure if he would search deeper into the mechanism of chemical reactions.

Geranium-Scented Boiler Rooms May Feature Future Power Plants. Diphenyl oxide, a white chemical with a powerful reek like geranium scent, raised to the *n*th degree, is the newest stunt in the efforts of engineers to get double work out of every shovelful of coal that goes into the firebox. The trick consists simply of using the chemical in one boiler to run one engine and then using the exhaust vapor from that engine, still very hot, to raise steam from ordinary water in a second boiler, according to Dr. H. H. Dow, manufacturing chemist of Midland, Mich. Dr. Dow has been experimenting with one of these bi-fluid boiler systems for some months and states that it has proved itself quite successful and very economical of fuel.

The idea of getting double use from the original firing of fuel was tried first with mercury as the liquid in the first, or high-temperature boiler. From certain points of view this metallic liquid is almost ideal, but its great weight and considerable initial expense, together with constant losses, interposed engineering and economic difficulties. Furthermore, any leakage of mercury vapor is almost certain to be injurious to the workmen in the plant, because mercury is exceedingly poisonous. For these reasons, therefore, Dr. Dow sought for another liquid that would be light, cheap, and non-poisonous, and still have high capacity for carrying heat over into the second boiler to generate steam for the second engine.

A number of organic chemical compounds were found to possess these qualities, but at the temperatures used in boilers they tended to break apart into other compounds useless for power purposes and to clog the boilers with carbonaceous materials of no use for carrying heat. Diphenyl oxide, however, has been used and recondensed and used over again many times at a pressure of 200 pounds per square inch and a temperature of 800°F., with but little deterioration. It weighs but little more than water, as contrasted with mercury, which is heavier than lead. Its price is only 30 cents a pound in quantity lots which, according to Dr. Dow, makes its cost, volume for volume, less than two per cent that of mercury. The compound has been produced hitherto in comparatively limited quantities, because its only use has been in the perfume industry, but Dr. Dow states that there is no limit on the bulk that can be manufactured if it is desired for power plant uses.—*Science Service*

POTASH

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It is our job systematically to build up sources of supply in all these raw materials which are now under monopolies. We must have adequate supplies to free us from these things in the future. The American people can help themselves. They don't have to ask anybody for help.

—HERBERT HOOVER

Where the Foreign Potash Monopoly Fits In

If there is anything the Great War taught us, it is the absolute necessity of permanently and economically establishing within the confines of our own country all of our essential industries. There occurs to the minds of all of us, as first among such essential industries, the supplying of food and clothing. These industries are fairly well established except for the necessary potash fertilizer for which we are still dependent on a foreign monopoly to the extent of 90 per cent of our demands.

Before the war we imported our potash almost entirely from Germany through a syndicate in which the government itself was a partner. This syndicate controlled the world supply and set the prices at which potash was sold. After France obtained control of the Alsatian deposits, there were two factors for a while in the potash situation. But in 1924 German and French interests made an agreement for export trade dividing this on a basis of about $67^1/_2$ per cent to the German producers and the rest to the French. Two years later, or in 1925, a new understanding was reached between the French Government and the German Syndikat, in which the Germans were allotted $65^3/_4$ per cent and the French $34^1/_4$ per cent. Consequently, the supposition that the division of the potash resources into both the French and German hands would break the monopoly was unfounded.

The potash monopoly has not inflated prices, due undoubtedly to the fear of stimulating foreign production, yet this monopoly is one of the strongest in existence and is practically government controlled. In fact, in 1910 after the Schmidtmann interest had temporarily broken away from the monopoly and had sold potash for a term of years considerably cheaper to the Americans than the monopoly prices, the German government stepped in and placed an export duty on the Schmidtmann potash sold at lower than monopoly figures, which procedure acted to deprive the Americans of the cheap potash and to make the German potash monopoly even more powerful than before.

As a measure to safeguard the productivity of our soils, we consider that it is the duty of the American chemist and the American business

man to join with Herbert Hoover in building up our own sources of supply for all such necessary raw materials as potash, nitrogen, rubber, and the like. But before going into this, let us ask ourselves just how potash acts.

What Does Potash Do?

Way back in 1860, Justus Von Liebig pointed out the necessity of potash for the growing of plants and he showed that potash is one of the three main mineral constituents that plants obtain from the soil and which are requisite for their growth. The other two are nitrogen and phosphates. The growing plants have a rather strong avidity for this potash, taking it up and leaving behind, in the soil, most of the soda. This is shown by the fact that the ashes of plants contain about 90 per cent of their total alkali as potash. In fact, without the potash plants will not grow. The certain condition for increasing the productivity of our soils which will be an absolute necessity as our population increases, will depend upon supplying potash and other fertilizers bountifully, even extravagantly, to the soils of this country.

At the present time, we use on every acre a very small amount of potash in comparison to the consumption of such European countries as Germany, Belgium, and Holland. To repeat, there is nothing more sure than that the consumption of potash per acre *must increase* from year to year as our demands for crops produced per acre increase. Are we going to continue to be dependent upon a foreign supply for this absolute necessity?

What Must Be Done to Make Potash Usable?

In order to use potash, either in agriculture or in other industries, it must be in water-soluble form. Even the potash from feldspars and other minerals which occur naturally in our soils must be converted into soluble form before the roots can take this into the plant and make it a part of the plant structure. So we must either find potash already existent in the soluble form, or we must change it by certain chemical processes to those forms soluble in water, and often we must eliminate impurities. Here is where the chemist steps in.

Some of these transformations are relatively simple, others are very complex and tax the fullest resources and knowledge of the physical chemist and of the engineer. Take the obtaining of potash from ashes of plants—this involves a simple leaching and evaporation to dryness to obtain a crude potassium carbonate which finds a ready market. Often these leached ashes are quite impure, but some give a very pure product, for example, the leached ashes of the sunflower stems.

Most of this potassium carbonate from sunflowers comes from Russia, and here history repeats itself as Russia was once a considerable factor in the world's potash markets, disappearing when the German deposits

were developed, becoming a factor during the early part of the war, and disappearing again.

It certainly must take a lot of sunflowers to yield a thousand tons of potassium carbonate, but many times a thousand tons have entered this country from Russia. During the war time, one large lot was a godsend to the tobacco growers of Kentucky, where they particularly like to have their potash in the form of an alkali.

The German and Alsatian deposits occur in layers with rock salt, and are the result of the desiccation of sea water over a long period of years. These salts are mined, brought to the surface, and sold in their crude form, but more often recrystallized under carefully controlled conditions in order to produce relatively pure compounds.

In our own United States potash occurs in many forms but it is only here and there that such deposits can be worked economically, and where such a desired result has been obtained it has been by adhering strictly to a few basic principles, among which can be enumerated:

(*a*) Recovery of by-products so as to reduce costs.

(*b*) Careful study—indeed intensive study of the physical chemistry of the reactions involved.

(*c*) Operation on such a scale as to distribute overhead and fixed charges and to cut the factory costs to a competitive basis.

(*d*) Such choice of the location of the fundamental raw materials that the transportation factors will not be too high.

What Are the Forms in Which Potash Is Used?

About 95 per cent of the potash consumed is for agriculture, the remaining 5 per cent entering a very diversified field in the form of a range of relatively pure potassium compounds.

We import a large part of our potash but we also make an important amount. Before detailing these amounts let us consider the yardstick by which we measure the purity of our potassium compounds. This yardstick or measure is the content of actual potash or K_2O contained in the salts. It is the actual potash that is of value to the farmer and so the non-technical broker or user has learned to buy and use his potassium compounds on this basis. In commerce quotations are often for a "unit of potash" which is 20 pounds of actual potash or K_2O. One hundred such units make a ton of potash. Such a yardstick is very convenient, for "manure salt" will contain only 20 per cent K_2O while some domestic potassium chloride will contain as high as 61.0 per cent K_2O (97 per cent KCl).

For agricultural purposes, Table I gives the principal potassium salts that are used.

In order to be used for agricultural purposes, the government specifies that potash materials must not contain over one-half of one per cent of

TABLE I

POTASH IN COMMON USE

Chemical name	Usual purity	Sold on basis of (in per cent)	Commercial name
Potassium Chloride (Domestic)	97%	97 KCl	Muriate of potash
Potassium Chloride	80–85%	80 KCl	Muriate of potash
Potassium Sulfate	90–95%	90 K_2SO_4	Sulfate of potash
Potassium Sulfate	48–53%	48 K_2SO_4	Double manure salt
Potassium Chloride	30%	30 K_2O	Manure Salt
Potassium Chloride	20%	20 K_2O	Manure Salt
Potassium Chloride	12.4%	.....	Kainit

borax, but there is no trouble at all in meeting this specification. The sulfate of potash is preferred for use on tobacco and, when so employed, should not contain more than three per cent of chlorine. Quite often it is advantageous to use, for tobacco, potash in an alkaline form, such as crude potassium carbonate. For most other crops, the chloride of potash is employed in the more or less pure forms listed above.

Turning now to the non-agricultural uses we find a great number of relatively pure potassium compounds that have an extended variety of uses.

TABLE II

IMPORTATIONS OF NON-AGRICULTURAL POTASH COMPOUNDS

		1924 Available content of K_2O			
	Usual purity, %	Short tons	Short tons	Percentage of total	Value
Bicarbonate	46.0	185	85	0.1	$ 25,754
Bitartrate (argol)	20.0	8,416	1,683	0.8	1,103,296
Bitartrate (cream of tartar)	25.0	766	192	0.1	165,421
Bromide	39.6	468	185	0.1	124,414
Carbonate, crude	61.0				
Carbonate, crude or black salts	50.0	3,569	2,177	1.1	290,396
Carbonate, refined	67.0				
Caustic	80.0	6,315	5,052	2.5	698,635
Chlorate and perchlorate	38.0	3,760	1,429	0.7	310,643
Chromate and bichromate	40.0	5	2	..	1,924
Cyanide	70.0	1,411	988	0.5	232,971
Ferricyanide (red prussiate)	42.0	41	17	..	25,308
Ferrocyanide (yellow prussiate)	44.0	132	58	..	40,032
Iodide	28.0	...	...	..	210
Nitrate (saltpeter), crude	40.0	772	309	0.2	54,628
Nitrate (saltpeter), refined	46.0	2,279	1,048	0.5	209,805
Permanganate	29.0	87	25	..	13,940
Rochelle salt	22.0	104	23	..	24,003
All other	50.0	26	13	..	4,172
		28,336	13,286	6.6	$3,325,552

This table does not cover all our non-agricultural uses, for some of the imported or domestic muriate or sulfate of potash is used to make other potassium compounds. For example, high-grade muriate is reacted with Chili saltpeter ($NaNO_3$) to form potassium nitrate, so extensively employed in the manufacture of certain qualities of high-grade glass or in the corning of beef. However, in the meat industry an especially purified nitrate of soda is now being extensively employed, displacing the more easily purified but more expensive potassium nitrate. Similar substitutions for a few other potassium salts such as potassium bichromate have taken place for the same reason.

However, there are many uses for the potassium salts and compounds in which the intrinsic properties of the potassium impart the desirable qualities. Such is true of caustic potash in the manufacture of soft or liquid soaps as the corresponding soda soaps are harder. Potassium salts are, as a rule, not hygroscopic and this property conditions the use of potassium nitrate in certain gunpowders.

In a host of miscellaneous industries the potassium compounds hold their own by reason of their "potassium nature" or by reason of their greater ease of purification or handsomer appearance. In chemistry, as well as in fashions, appearance and style count heavily in selling and many a chemist has devoted hours to improving the appearance of his product—even after the purity has been attained. Potassium compounds are similar to the ladies in this respect—they "like to be dolled up."

In medicine, pharmacy, photography, textiles, and lakes many potassium compounds are used. Among such are potassium iodide and bromide; potassium citrate, tartrate, ferrocyanide, ferricyanide, and hypophosphite. Also potassium chlorate is employed in medicine and in the explosive industry. It is said that we of these United States use 250,000,000,000 of safety matches each year and potassium chlorate and perchlorate are essential constituents.

In electroplating, the articles to be plated must be free of every trace of grease or else the plating metal will not adhere, so a bath of caustic potash is used because of the great solubility of potassium soaps or grease compounds.

How Much Potash Is Used and Where Does It Come From?

Germany has in the past been quicker to follow what scientists have pointed out to be the most rational lines, and so we find that Germany leads in point of consumption of potash, with 825,000 short tons K_2O; the United States next, with 300,000 tons; then comes France, 120,000; Holland, 100,000; Great Britain, 50,000; Sweden, 35,000; Denmark, 25,000; other European countries 70,000; other foreign countries, 100,000. While the American consumption is large in tonnage, it is low in amount used

per acre. The heaviest United States consumption is in the Eastern and Southern coastal plain sections, with an increasing demand in the central areas. Potash is used largely for cotton, fruit, tobacco, truck, and root crops. On peaty or muck lands it gives unusual results. Consumption of potash in this country in 1925 exceeded the pre-war figure for the first time. Included in these tonnages are the relatively small but necessary amounts which are used for the chemical and allied industries. It is estimated by competent authority that the above tonnages were produced in 1925 from the following countries:

Germany	1,300,000 tons actual potash (K_2O)
Alsace	300,000 tons actual potash (K_2O)
United States	24,000 tons actual potash (K_2O)

What Is the Ultimate Source of Potash?

At one time on the earth there was neither soil nor sea, only rocks or air or vapor, so we must turn to the rocks or the rock magma as the primal source of potash and other non-gaseous products. And of the various rocks, the first were naturally the igneous from which the others have been derived literally by the coming and going of the sun.

For practically daily interest, the data that Frank Wigglesworth Clark has gathered in his monumental work on geochemistry is very timely. Let us tabulate the facts that Clark presents on the amount of potash in the rocks.

TABLE III

DISTRIBUTION OF POTASH

Variety of rock	Percentage of rock variety in total lithosphere	Percentage in total weight of earth	Percentage of K_2O
Igneous	95		3.05
Shale	4		3.24
Sandstone	0.75		1.21
Limestone	0.25		0.33
* * * * * * *			
Entire lithosphere		93	2.98
Hydrosphere		7	0.045
Weighted average including the atmosphere			2.75

Plants selectively absorb potash from the potassium minerals contained in soils, but the decomposition of these minerals is so slow that we need to fertilize with soluble potassium compounds.

Practically we get a large proportion of our potash from the concentration that has taken place from the evaporation of that relatively small amount contained in the hydrosphere, that is, from sea water or other aqueous deposits. The reason is that such sources are cheaper to work,

yet the day is dawning, particularly here in America, when the more refractory potash minerals will be forced to yield up their treasures. This will come largely from making potash from greensand, from shale or ores, and as a by-product in the manufacture of bricks, cement, or iron or other commodities.

Actually most of the potash we use is from such deposits as those at Stassfurt or Alsace or Searles Lake, California, wherein the potash originally present in the igneous rocks has been leached into water solution and then concentrated by evaporation.

But plants do yield an appreciable tonnage in the form of carbonate from ashes, bitartrate from wine, and mixed salts from molasses.

What Are the Foreign Sources of Supply?

It was known for a long time that potassium salts accompanied the enormous salt deposits of Stassfurt, but it was not until the Schmidtmann interests put down core drills lubricated with a saturated saline solution that accurate core drillings were obtained which definitely established the extent of the German potash resources. It was then only a matter of time before these deposits were commercially developed and assumed the dominating place they now occupy in the world's markets. The Alsatian deposits are somewhat similar to the German ones, and they both are worked by bringing the crude salts to the surface, where they are either sold as such, or purified by crystallization under closely controlled conditions.

Development has been progressing for some time on the Spanish potash deposits in which salt is accompanied by sylvinite (KCl) and carnallite ($KCl.MgCl_2.6H_2O$) and are hence related to the deposits of Germany and of Alsace. It is said that these mines will be in commercial operation very soon.

A summary of the world's production of potash minerals is collected by the U. S. Bureau of Mines and the table on the next page is from their excellent report.

What Are the American Sources of Supply?

During the war, when the foreign importations of potash were shut off, we started to produce potash from a number of different sources. The American producers were not able to meet the demands and the prices rose to unheard-of figures, and as high as $500.00 per ton was obtained for high-grade muriate. Acting under this stimulus, a great number of plants started up throughout the United States, most of which succumbed to competition when prices fell to normal condition again.

However, a few plants have taken advantage of scientific research and have produced by-products which enabled them to place their production on a competitive basis.

TABLE IV

WORLD PRODUCTION OF POTASH MINERALS

Country and mineral	1922 Output	1922 K_2O content	1923 Output	1923 K_2O content	1924 Output	1924 K_2O content
Abyssinia, chloride of potash	[a]	[a]	[a]	[a]	[a]	[a]
Australia:						
New South Wales, alunite	188	23	1,014	82	[a]	[a]
South Australia, alunite	97		.....	....	[a]	[a]
Austria (Galicia), kainit and sylvinite	[b]	[b]	[b]	[b]	[b]	[b]
Canada, natro-alunite	45	[a]	14	[a]	[a]	[a]
China[c]	493	[a]	479	[a]	[a]	[a]
France (Alsace), crude salts	1,326,859	211,675	1,568,000[d]	248,528	[a]	271,624
Germany, crude salts	13,012,320	1,509,850	[a]	885,942[e]	[a]	824,000[e]
India, British:						
Nitrate of potash	11,673	4,744	8,692	3,542	[a]	[a]
Other salts	.....	.....	.....	.....	[a]	[a]
Italy:						
Alunite	.....	.....	135	[a]	[a]	[a]
Leucite	18,000	[a]	8,720	[a]	1,850	[a]
Japan, alunite	1,178	100	[a]	[a]	[a]	[a]
Poland:						
Kainit	2,520	15,479	22,128	29,404	81,000	[a]
Sylvinite	43,563		39,375			
Spain, nitrate of potash	[a]	[a]	76	51	[a]	[a]
United States, crude salts	22,839	10,627	35,406	18,339	39,661	20,771

[a] Data not available.
[b] Included under Poland.
[c] Exports.
[d] Reported as sylvinite, but believed to be crude salts.
[e] Figures relate to sales.

The rise, decline, and stabilization of the American potash production is strikingly shown in the accompanying table compiled by the U. S. Geological Survey and the Bureau of Mines (except for the 1925 estimate):

TABLE V

POTASH PRODUCED AND SOLD IN THE UNITED STATES, 1916–1924

Year	Number of plants: Total	Number of plants: Exclusive of producers of wood-ash potash	Production: Crude potash (short tons)	Production: Available content of K_2O (short tons)	Sales: Crude potash (short tons)	Sales: Available content of K_2O (short tons)	Sales: Value f. o. b. plant
1916	70	25	35,739	9,720	35,739	9,720	$ 4,242,730
1917	95	46	126,961	32,573	126,961	32,573	13,980,577
1918	128	77	207,686	54,803	140,343	38,580	15,839,618
1919	102	67	116,634	32,474	166,063	45,728	11,271,269
1920	66	49	166,834	48,077	139,963	41,444	7,463,026
1921	20	19	25,485	10,171	10,337	4,408	447,859
1922	12	12	25,176	11,714	22,028	11,313	463,512
1923	12	12	39,029	20,215	35,164	19,281	784,671
1924	11	11	43,719	22,896	37,492	21,880	842,618
1925 (estimate)				24,000			

TABLE VI

POTASH PRODUCED, SOLD, AND IN STOCK IN THE UNITED STATES IN 1924, BY SOURCES

	Organic: Molasses distillery waste	Organic: Steffens water from beet-sugar refineries	Mineral[a] (natural brines, dust from cement mills and blast furnaces)	Total
Production:				
Number of plants reporting	1	1	9	11
Crude potash, short tons	10,302	600	32,817	43,719
Available content of K_2O:				
Short tons	3,430	72	19,394	22,896
Percentage of total	15	....	85	100
Sales:				
Number of plants reporting	1	1	7	9
Crude potash, short tons	947	600	35,945	37,492
Available content of K_2O, short tons	315	72	21,493	21,880
Value f. o. b. plant	$19,055	$4,800	$818,763	$842,618
Stocks on hand Dec. 31, 1924:				
Number of plants reporting	1	....	9	10
Crude potash, short tons	27,749	....	4,596	32,345
Available content of K_2O, short tons	9,238	....	1,507	10,745

[a] Of the plants reporting on potash from mineral sources two obtained it from natural brines and the rest from cement-mill or blast-furnace dust.

The chief production is from California and the brine of Searles Lake is the important raw material. Here the American Potash and Chemical Corporation, successor to the American Trona Corporation, have their splendid plant, where, by a combination of business sagacity and deep scientific investigation, they have established their operations on a firm basis and as the chief American production.

The Company pumps in the brine from Searles Lake and evaporates it under such controlled conditions that certain of the undesirable impurities—salt, sodium, carbonate, and sodium sulfate separate out. The sodium carbonate and sodium sulfate separate as a new mineral which they have named "Burkeite." The concentrated brine is then allowed to cool to yield first potassium and later borax. This sounds like a simple

Plant of the American Potash and Chemical Corporation

procedure, but physical-chemical work of a high order had to be done on salt equilibriums before the exact and necessary conditions could be established to give commercial yields of products of the high purity furnished by this company.

TABLE VII

POTASH PRODUCED IN THE UNITED STATES IN 1924, BY STATES

State	No. of plants	Crude potash short tons	Available content of K_2O	
			Short tons	Percentage of total
California	3	22,121	19,361	84.6
Maryland	1	10,302	3,430	15.0
Indiana, Pennsylvania	1, 6	1,296	105	0.4
	11	43,719	22,896	100

An important Eastern producer located in Maryland is the U. S. Industrial Alcohol Co. which makes a mixed potassium salt from the liquors resulting after the distillation of alcohol from fermented molasses.

The other American producers are half a dozen blast furnaces, a sugar company, and a cement mill. Here the potash is collected as a by-product and sold as a fertilizer. This line of recovery will probably be developed to a large extent in the future.

What Can We Do to Permanently Meet Our Potash Needs from American Raw Materials?

It is generally accepted that it would be most desirable to have at least a large part instead of a small portion of our ever-increasing potash requirements met from domestic production. To do this we must follow in the steps of our successful producers and combine careful physical, chemical, and engineering work with business foresight and resources. This is no field for dabblers. Furthermore, all by-products must be commercialized.

Plant of the U. S. Industrial Alcohol Co.

Even with such a procedure it is doubtful, except in favorable localities, whether success will be attained without tariff protection to help such industries over the initial and expensive development stages. We can only pick out the resources favorably located, intensively study them, their reactions and by-products. We have plenty of potash resources. Can

we commercialize them so as to supply a large part of our potash demands? The answer lies with the American chemist backed by the American engineer and far-sighted American men of business.

Engineers Find Heaviest Gasoline Most Economical. The burning question as to what fuel gives the most miles per gallon most satisfactorily when used in American automobiles has been studied by the Society of Automotive Engineers and the results announced by Dr. H. C. Dickinson of the U. S. Bureau of Standards and the Massachusetts Institute of Technology.

One of the conclusions startling to the average driver is that the ton miles per gallon obtained is independent of the ease with which the gasoline evaporates. The experts, therefore, conclude that the heaviest fuel is the most economical.

Other conclusions arrived at after four years of tests on the part of the U. S. Bureau of Standards, the research department of the Society of Automotive Engineers, ten automobile companies and the petroleum industry, are:

"Gasoline consumption is somewhat greater in winter than in summer.

"Dilution of crankcase oil is consistently greater the heavier or less volatile the fuel.

"Dilution of crankcase oil is much greater in cold weather than in warm.

"Small differences in the initial volatility of the fuel have a large effect on engine starting.

"Starting performance of the fuel is the quality most readily noted by the driver."

Economy dictates the use of as heavy a fuel as possible, Dr. Dickinson explained, but a practical limit in this direction is set by the dilution of crankcase oil and the difficulty in starting.

On account of the limiting factor of the thinning of the crankcase oil, an extensive survey was undertaken to determine the methods of reducing dilution. The following recommendations were made: Operate with high cylinder wall temperature; reduce the time required to reach normal operating temperature; always use as lean mixtures as practicable; operate with high oil temperature; ventilate the crankcase.—*Science Service*

Chemist Visions Longer Life in Next Half Century. A chemist, Dr. H. P. Cady of the University of Kansas, looked forward fifty years into the future in his vice-presidential address before the chemical section of the American Association for the Advancement of Science and this is what he saw:

Longer human life due to spectacular advances in the overlapping fields of organic chemistry, physiological chemistry, and medicine.

Manufacture of rubber, oil, and other essential industrial materials from chemicals so as to make man partially independent of natural processes and stores of such substances.

Photosynthesis of carbohydrates, such as plants now make, from nitrogen, water, and carbon dioxide.

Metallic materials having almost any desired properties.

Transmutation of one element into another with such facility that chemistry students will yawn at demonstrations.

Formation of new theory of constitution of matter to supplant present complex and conflicting theories of atomic structure.

Millions of compounds of carbon where only a few hundred thousand are now known.

Students taking advantage of prolonged life to master all the new knowledge of chemistry.—*Science Service*

AN IMPROVED METHOD OF RECORDING THE RESULTS OF QUALITATIVE ANALYSIS

HAROLD HODGE, UNIVERSITY OF IOWA, IOWA CITY, IOWA

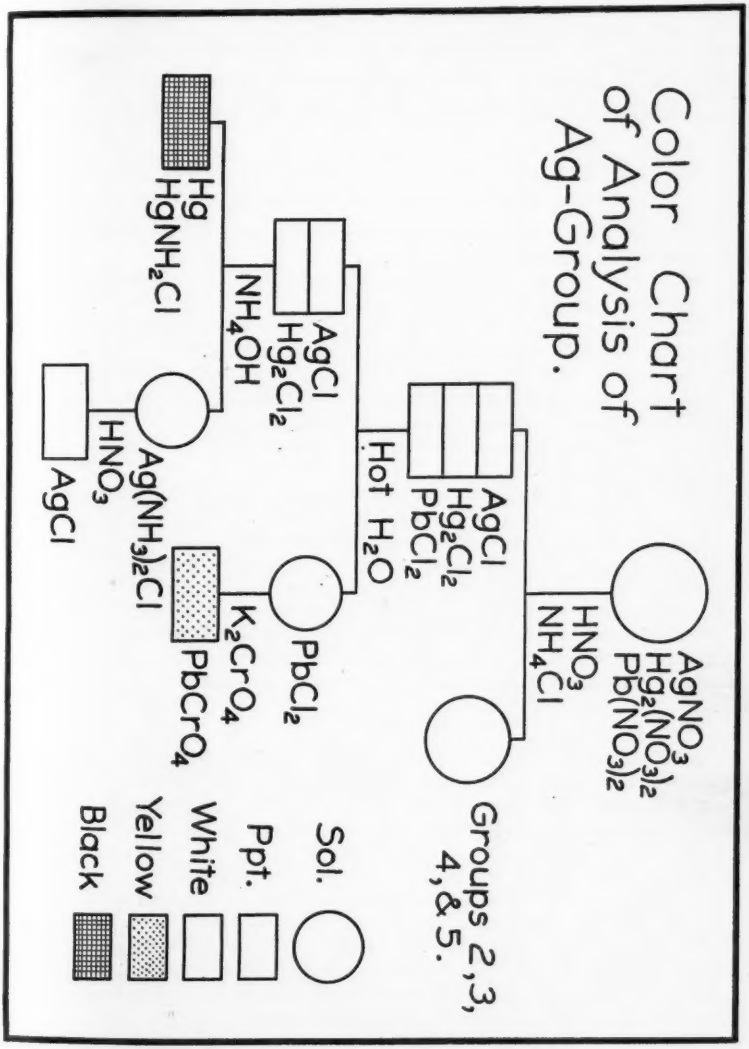
The following method embodies an effort to provide a means of graphically recording not only the presence of precipitates, but also the color of solutions and precipitates throughout a qualitative analysis. The system here described is an elaboration of the "Plum-tree" outline that has been in use in this laboratory for many years. The "Plum-tree" (see figure) is a short, graphical representation of procedures, drawn with lines from the result of one reaction to the result of the next reaction, the reagents used being written across the vertical lines in the sequence of their addition. The new method extends the form of the "Plum-tree" to indicate the presence of solutions by circles and of precipitates by rectangles. By coloring the circles and rectangles, the record is made of the corresponding colors of solutions and precipitates, as shown.

The method was developed in connection with the laboratory course in qualitative analysis for engineering students. At the beginning of the course, each student provided himself with a box of colored crayons. In the preliminary work with known substances the method of recording qualitative analytical results here described was used. Then at the completion of the preliminary work and after studying the theory of the experiments as given in A. A. Noyes, "Qualitative Analysis," each student made a formal chart according to the best practices of mechanical drawing setting forth the complete analysis of the group. Done in turn for each of the groups, the record thus formed of each group was added to all that had gone before so that at the end of the course each student had a complete record of the entire scheme of qualitative analysis recorded on one side of one sheet of paper.

The students found that this method recorded a valuable part of the observable procedure, a part usually overlooked. The use of the colors as sign boards for results saved many fruitless hours of work. The colors recorded were useful not alone to the students but proved an aid to the instructor as well. The students soon became convinced that close observation payed big dividends in heightened accuracy and shortened work, and the instructor found the edifying record of colors a blazed trail to accurate advisement.

After the preparation of a chart, many students found that they viewed the analysis in the light of a purposive, organized synthesis of processes, and not as a collection of recipes, which latter impression (be it regretted) holds the minds of many students of qualitative analysis. Essentially a mechanical appliance, the chart was suited to a class of engineers. How it would work for a class of Liberal Arts students we are not prepared

to say. However, the average L.A. student needs a chance to work with his hands. The students liked to use the method. Results in



examinations showed that the section using this method was superior to sections using ordinary methods in their ability to apply the principles of qualitative analysis to particular cases.

Summary

A graphical method is proposed for recording in a qualitative analysis:

1. The reagents added,
2. The results produced,
3. The separation of solid from liquid, and
4. The color of the solutions, precipitates, and filtrates.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Associate Sanitary Engineer.

Applications for associate sanitary engineer must be on file at Washington, D. C., not later than February 21st.

The examination is to fill a vacancy in the United States Veterans' Bureau, and vacancies occurring in positions requiring similar qualifications.

The entrance salary for this position in Washington, D. C., is $3000 a year. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions. If appointment is made outside the District of Columbia, the salary will be approximately the same.

The duties are to investigate water and sewage problems at the various Veterans' Hospitals; to advise in regard to water supplies and the design of water and sewer systems; to carry on bacteriological and chemical investigations of water. The work will include travel, as required, to the various field activities of the Bureau.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience.

Full information and application blanks may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post-office or customhouse in any city.

X-Ray Overdoses Hurtful to Plants. X-rays can have harmful effects on plants as easily as they can on animals, and the result of an apparently mild dose given to a plant in its youth may show up in distortions and freak growths much later, when maturity has been reached. A series of experiments with X-rays on plants, conducted by Edna Louise Johnson of the University of Colorado, is to be reported in the forthcoming issue of the *Botanical Gazette*.

Miss Johnson used sunflowers for her material, raying them while they were young seedlings and even unplanted seeds. Then she let them grow up and watched for results. Most of the plants developed doubled, or "fasciated," stems, a phenomenon occasionally observed in nature, caused by injury to the growing tip. The doubling tendency extended to leaves and flowers as well, for many leaves had two blades and some of the flower heads appeared in distorted and unnatural shapes.

The effects of the X-rays were evident internally as well as externally. The stem was made coarser and woodier, its water-conducting vessels were dislocated from their usual positions, and abnormal amounts of corky material appeared in the skin. Measurements of physiological effects showed that the rate of life-processes in general was depressed.—*Science Service*

A LECTURE-TABLE DEMONSTRATION OF BOILING-POINT ELEVATION

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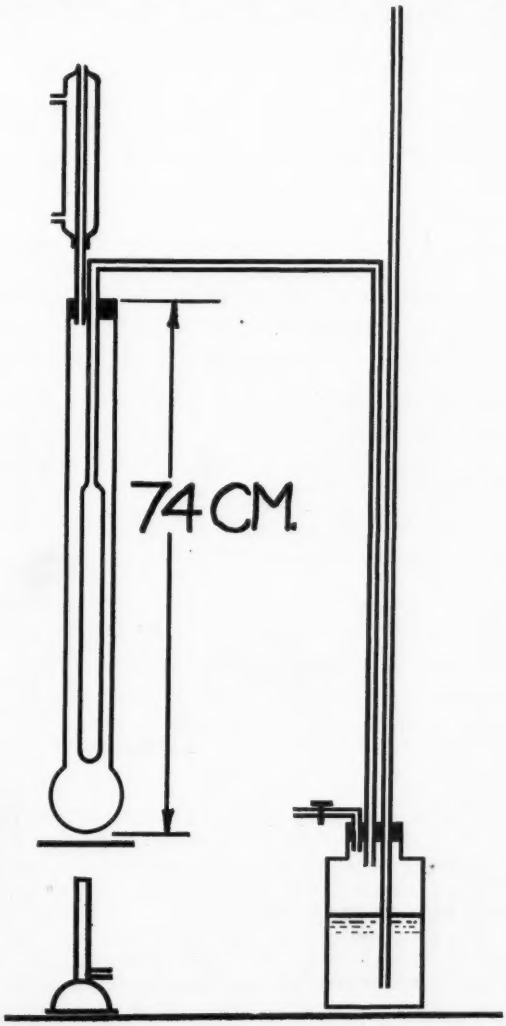
The apparatus shown in the figure uses some very old and familiar ideas to accomplish a particular purpose, viz., a simple and positive demonstration of boiling-point elevation visible to all students in a lecture room



of fair size. The apparatus shown was easily made from a Victor Meyer apparatus. The inner tube of the Victor Meyer apparatus was cut just above the bulb and connected, by a capillary tube, to the manometer at the right.

To operate, the water in the outer jacket is caused to boil for several minutes. Then the meniscus in the manometer is adjusted to a suitable height by means of the cock inserted in the rubber stopper in the bottle. Finally, after the meniscus remains stationary for several minutes, its position is marked, then by adding about 100 cc. of syrupy orthophosphoric acid to the boiling water through the reflux condenser, the boiling point of the water is elevated and the meniscus is raised about one foot. A second 100 cc. portion of acid causes a second foot of rise and similarly with a third addition. With colored water in the manometer this rise is visible for some distance. Tight joints and absence of moisture in the inner system are essential. We found that rubber stoppers in bottles usually form tight joints more readily than rubber stoppers in flasks.

A quite satisfactory application of this same idea may be had by substituting for the Victor Meyer apparatus a rubber-stoppered test tube submerged in a beaker of boiling water and connected by a rubber tube to the manometer. Of course, the elevation of the meniscus is not so great.

Teacher's Quality Depends upon Length of Training. The public, taxed to support the public schools, is naturally anxious to have teachers of high quality. That lengthened professional training is necessary to produce teachers of this caliber was stated by Dr. L. A. Pechstein, dean of the college of education of the University of Cincinnati, speaking before the American Association for the Advancement of Science.

The two-year normal schools need to extend their program of training, he said. The graduate of a two-year normal school, or the teacher with even less training, is not prepared to give the grade of teaching desired by the public. She is apt to be too young, to come from a family weak in cultural influences and to be entering upon her profession solely because of the need to earn money. On the other hand, Dr. Pechstein stated, the extended college and university course produces teachers of greater maturity, drawn from families of higher social and economic groups, who enter upon their careers with a more intellectual outlook.—*Science Service*

Leper Deformities May Yield to Science. Dr. Paul A. McIlhenny has reported to the American Medical Association on preventive methods that may head off many of the frightful deformities long associated with leprosy. At the national leprosarium at Carville, La., corrective treatments consisting of massage, baths, exercise, and ultraviolet irradiation have been used with success in treating the misshapen hands and feet even of cases of long standing, says the specialist.

Since very little preventive work of this character has ever been attempted in leper colonies, physicians are watching the progress of these corrective methods with great interest. So many deformities have been improved that in time cures of the less severe deformities are not regarded as impossible.—*Science Service*

Chemical Digest

SCIENCE IN PRACTICAL AFFAIRS

As a means of applying engineering knowledge to problems of government, industry, and commerce, a "Division of Municipal and Industrial Research" has been organized at the Massachusetts Institute of Technology, according to a recent report. In making this announcement, President Samuel W. Stratton said he believed the new division to be the first of its kind established in an educational institution. Funds for establishment of the division came from John E. Aldred, New York banker and industrialist.

A method whereby the tropical seas might be harnessed to drive huge electric generators has been demonstrated before the French Academy of Science by George Claude, inventor of liquid air. The theory upon which the device is based employs the difference in temperature between surface water heated by a tropical sun and that of water taken from a great depth. Water at surface temperature near the tropics will boil when introduced into partial vacuum and the steam thus generated would be used to drive turbines coupled to electric generator units.

Establishment of a division of history in the National Academy of Sciences is urged by Prof. Michael I. Pupin of Columbia University, internationally known for his discoveries in electricity. Prof. Pupin is a past president of the American Institute of Electrical Engineers and a member of the American Engineering Council. History is our most important science, Prof. Pupin declared in a statement issued through the American Historical Association. Prof. Pupin is a member of the New York City Committee headed by Charles S. Hughes which is aiding the Association in its nation-wide campaign for a $1,000,000 research endowment.

Following the establishment by John D. Rockefeller of an endowment for the purpose, a series of studies in the origin, distribution, and properties of petroleum is to be inaugurated under the auspices of the Amer-

ican Petroleum Institute and the National Research Council. A half-million dollar fund has already been provided to finance the work for five years. The results will be of utmost significance as bearing on the present status and future development of the industries based on petroleum. Announcement of the projects and of the plan for carrying on the studies has just been made by the American Petroleum Institute. Mr. Rockefeller initiated the program of scientific research in geology, physics, and chemistry of petroleum in November, 1925, stipulating that the results were to be freely available to the industry and the public. In January, 1926, the Universal Oil Products Company of Chicago in furtherance of the same program gave an additional $250,000, payable in annual instalments of $50,000 each.

The United States Bureau of Mines announces that a practical and economical process has been developed for carbonizing low-grade lignite coals which will make possible the commercial development of the vast unused lignite deposits of the country. Since nearly one-third of the known coal deposits of the nation consists of this form of fuel, the importance of a successful commercial process of carbonization is apparent. The finished product obtained by means of the process is a fuel in the form of briquets. It is believed that, by means of the new process, the lignite coal of the Western states can compete successfully with the more highly volatile fuels of other regions. The successful utilization of the lignite coals of the western United States would mean much to the industrial prosperity of that region. The transportation charges upon coal have always, in the past, been a limiting factor in the growth of local manufacturing throughout the region lying between the Mississippi River and the Rocky Mountains. The development of the great untouched fuel resources of the region would unlock an immense store of new wealth. The mineral and agricultural resources of the region are great. The West may well look forward to an industrial expansion similar to that which is taking place today in the South.

Figures recently prepared by the National Industrial Conference Board concerning the huge amount of public money spent annually for education of the children of the residents of this country are illuminating in the extreme as they demonstrate one of the several reasons why our young people forge ahead so rapidly upon entering business. It has been brought out by the Conference Board that in 1924 there was expended for the

support of primary, grammar and public high schools almost $2,000,000,000, or a per capita expense of $16.25 for every resident. This was almost five times as much as was spent for the same purpose in 1900. Nor do these figures include the amounts spent for parochial schools, seminaries, colleges, academies, and other private institutions of learning most of which are endowed or otherwise self-supporting. Were these schools taken into account the gross amount spent in the United States annually for education would approximate $3,500,000,000 spread over some 264,000 school buildings wherein is offered instruction to about 25,000,000 pupils daily. Two facts about the school figures compiled by the Industrial Conference Board are of exceptional interest; that the far West is outstripping other parts of the country in the amount spent per capita for public schools and that the South lags behind. California spent in 1924, $159.35 per child of school age and Nevada and Wyoming followed in order. Oklahoma spent $46.04 per child and Arkansas only $15.85.

One of the most rapidly growing groups of industries in the United States is that based on chemical science. For instance, in 1914 we imported almost 46,000,000 pounds of dyestuffs and produced 6,600,000 pounds. In 1925, by contrast, our imports were 5,300,000 pounds and our production was 86,000,000 pounds. Recent figures show that whereas in 1914 the output of our principal chemical industries was $4,800,000,000, in 1923 it was $11,732,000,000, an increase of about 144 per cent. There are now more than 1,000,000 persons employed in these industries. One of the most interesting divisions of chemical engineering is the manufacture of pyrolin plastics of which celluloid is the best known. Although the output in 1914 was $13,895,800 this increased to $77,477,000 in 1919. With rubber substitutes, viscose and other plastics included, the total value of all plastics produced in this country in 1923 was $102,229,807. Figures also indicate that electrochemical methods of manufacture are becoming constantly more popular. The output in 1914 was worth only $29,661,949 but in 1923 the value jumped to $107,230,789. Industry is embarking on a period of research, a study of how to cut cost and operate more smoothly. Chemistry is coming more and more to be recognized as the great essential science.

ANNIVERSARIES OF SCIENCE

Recently *Science Service* has added a new department headed, "Today in Science," in which the anniversaries of important steps in the history of science are noted. Among them we find the following:

The first of Hertz' papers establishing the similarity between light and electric waves was presented before the Berlin Academy of Sciences on November 19, 1887. The following quotation is taken from Mills, "The Realities of Modern Science:"

In 1873 Maxwell, who was a prominent physicist, highly trained in the use of mathematical tools, announced that light was an electrical phenomenon and traveled as an electromagnetic wave. He further stated the possibility of there being other electromagnetic waves which would not produce the effect of light but would travel just as light waves travel.

In 1887 Hertz verified this prophecy of Maxwell and announced the discovery of electromagnetic waves. Hertz studied their properties or characteristics. He showed how they could be produced, how they traveled through the walls of buildings and were not affected by obstacles which would completely obstruct the passage of light, and also how they could be detected, since they do not affect the eyes as does light.

Röntgen rays were discovered November 8, 1895. In an "Interview with Professor Röntgen," by H. J. W. Dam in *McClure's Magazine*, Volume VI, page 413, is quoted:

I was working with a Crookes' tube covered by a shield of black cardboard. A piece of barium platino-cyanide paper lay on the bench there. I had been passing a current through the tube, and I noticed a peculiar black line across the paper.

What of that?

The effect was one which could only be produced in ordinary parlance, by the passage of light. No light could come from the tube because the shield which covered it was impervious to any light known, even that of the electric arc.

And what did you think?

I did not think; I investigated. I assumed that the effect must have come from the tube, since its character indicated it could have come from nowhere else. I tested it. In a few minutes there was no doubt about it. Rays were coming from the tube, which had a luminescent effect upon the paper. It seemed at first a new kind of light. It was clearly something new, something unrecorded.

The last of Hertz' researches on the relation between light and electric waves was presented before the Berlin Academy of Sciences on December 13, 1889. Quoting Sir Oliver Lodge in his paper on "The Modern Theory of Light," published in the *University College Magazine*, July, 1889:

It is light, just as good as any other light. It travels at the same pace, it is reflected and refracted according to the same laws; every experiment known to optics can be performed with this etherial radiation electrically produced, and yet you cannot see it. Why not? For no fault of the light, the fault (if there be a fault), is in the eye.... These electro-magnetic waves have long been known on the side of theory, but interest in them has been immensely quickened by the discovery of a receiver or detector for them. The greatest though simple discovery by Hertz of an "electric eye" as Sir W. Thompson calls it, makes experiments on these waves for the first time easy or even

possible. We have now a sort of artificial sense organ for their appreciation, an electric arrangement which can virtually "see" these intermediate rates of vibration.

On December 15, 1859, Gustav Kirchhoff communicated to the Berlin Academy of Sciences the principle that glowing vapors absorb the same radiations that they emit, thus accounting for Fraunhofer lines in the solar spectrum. According to Frank Schlesinger in his "Astronomy in the Development of the Sciences,"

> The spectroscope was turned to the sun and some of the innumerable dark lines in its spectrum were mapped by Fraunhofer. But it was not until 1859 that Kirchhoff and Bunsen found the key to these lines; they showed that most of them are caused by absorption in the very shallow and comparatively cool atmosphere of the sun. Each element has its characteristic lines which appear wherever the absorption takes place whether in the laboratory, in the sun or elsewhere. Here then is a means of analyzing the sun in the chemist's sense. It is found that almost all common elements that we find at the surface of the earth are also plentiful in the sun.

Prof. Samuel F. B. Morse, on December 16, 1842, in testing out his telegraphic system in Washington, so arranged his wires along the banks of the river as to cause the water itself to conduct the electricity across. The current was carried across the canal and a few feet down the bank by wires and then back by the water of the canal. This was the first telegraphy without wires.

On December 16, 1902, Marconi dispatched the first wireless message across the Atlantic Ocean.

Orville Wright flew the first heavier-than-air machine for the first time on December 17, 1903. In a paper read before the American Association for the Advancement of Science, December 30, 1903, on "Aerial Navigation," O. Chanute says:

> Practical efficiency was acquired by the Wright brothers, whose flying machine was successfully tested on the 17th of December. For three years they experimented with gliding machines....and it was only after they had obtained thorough command of their movements in the air that they ventured to add a motor. How they accomplished this must be reserved for them to explain, as they are not yet ready to make known the construction of their machine nor its mode of operation.

Sir Humphry Davy was born on December 17, 1778. Bolton in his "Famous Men of Science" says:

> His first experiments were the effects of acids and alkalies on vegetable colors, the kind of air in the vesicles of common seaweed, and the solution and precipitation of metals. These were made in his bedroom in Mr. Tonkin's house, or in the kitchen when he required fire. This old gentleman had brought up his mother and her two orphan sisters, and now was like a father to Humphry. He said, "This boy, Humphry, is incorrigible.

Was there ever so idle a dog! He will blow us all into the air." He was at this time probably making a detonating composition, which he called "thunder power," his sister Kitty being his assistant.

James Watt obtained the first of his four patents for a steam engine on January 5, 1769. T. C. Bridges in "The Young Folk's Book of Invention" says:

When Watt grew up he became an instrument maker at Glasgow University and it was here that a model of Newcomen's steam pump was brought to him one day for repair. This engine.... wasted steam in a shocking fashion, for since at every stroke cold water was driven into the cylinder to condense the steam, most of the energy of each fresh inrush of steam was wasted in reheating the cylinder. Watt resolved to find some way of preventing this waste, and for two whole years spent nearly all his spare time in puzzling out the problem.... As he was taking a walk one fine Sunday in 1765, suddenly, as he says himself, "the whole thing was arranged in my mind." His great idea was to connect to the working cylinder a vessel into which the steam could be exhausted for condensation so that it would be possible to keep the cylinder itself constantly hot.

Francis Bacon was born January 22, 1560 or 1561. In Sedgwick and Tyler's "A Short History of Science," we find the following:

Bacon, because of his official position and immense philosophical and literary ability, was able to draw universal attention to the methods of science and especially to the method of investigation of induction, so that his indirect service to science was great. Bacon's true place in science was, however, well understood by his contemporaries, for one of the greatest, Harvey, discoverer of the circulation of the blood, remarks that, "the Lord Chancellor writes of science like—a Lord Chancellor."—Sedgwick and Tyler: A Short History of Science.

Robert Boyle, "Father of Chemistry," was born January 26, 1627. In his book "The Sceptical Chymist" he writes:

Me thinks the Chymists in their search after truth are not unlike the navigators of Solomon's Tarshish Fleet, who brought home from their long perilous voyages not only gold and silver and ivory but apes and peacocks too; for so the writings of several (I say not all) of your hermetick philosophers present us, together with diverse substantial and noble experiments, theories which, either like peacocks' feathers, make a great show, but are neither solid nor useful, or else like apes, if they have some appearance of being rational, are blemished with some absurdity or other that, when they are attentively considered, makes them appear ridiculous. W. R. W.

Sunlight Found Not So Good for Fish. The ultra-violet radiation in sunshine may be a great help to birds and beasts and man but fish fail to appreciate these invisible rays.

Experiments undertaken at a Vermont hatchery and just reported to the U. S. Bureau of Fisheries, definitely establish that sunlight is harmful rather than helpful to fish. Almost twice as many young fish died in troughs of water exposed to direct sunlight as those in troughs left in the shade, experts found. The experiments were repeated with different ages and different species with sometimes an even greater mortality in the unshaded troughs, it is stated.—*Science Service*

ABSTRACTS

What Research Has Done for Secondary Education. A. E. BROWN. *Sch. Bd. J.*, **73**, 41–3 (1926).—One means of human progress is the "substituting of science for guesses to obtain control of the values of life." The character of the high-school population has been changing, as is apparent from research statistics. The great growth, which is pointed out by Thorndike, has resulted in a lower mental level, a fact which must be borne in mind by those preparing text-books.

Intelligence testing has given a tentative standard of mental ability required for the different grades of school work; high-school work of any grade demanding an I. Q. of at least 100, while an I. Q. of 110 seems necessary for successful work in college. Statistics show that over age usually accompanies failures and that repeaters neglect to consider their work seriously. To advise students occasionally of the results of their studies seems advantageous, and encouragement means much, particularly to the slower students. Whether the lecture or the question and answer method is better depends on the individual, for statistics show that students vary in their reaction. The gifted child should not be held back with the slow and those of average intelligence. Certain fundamentals should be required of him but he should be allowed to learn these in less time and permitted to go on, enriching his experience in other fields. The value of segregating students on the basis of ability is still under discussion.

Experimentation has not revealed any value in limiting classes to twenty-five, as has been done in many schools. That the new type of examinations, those consisting of a comparatively large number of "key questions" which require short answers are preferable to the old-fashioned type requiring long, explanatory answers has been recognized for a number of years.

The author, in concluding, states that the possibilities of useful research in the secondary field of education have scarcely been tapped. There is no reason why experimental studies in this field should not be summarized and made available for the teacher and administrator. K. S. H.

The Separation of Magnesium from the Alkali Metals. CARL OTTO. *J. Am. Chem. Soc.*, **48**, 3016–9 (Dec., 1926).—A simple and almost quantitative method is proposed for the separation of magnesium from sodium and potassium. The filtrate from other metals is evaporated twice to dryness with nitric acid, whereby almost all other anions present will be expelled. Ignition of the residue until ammonium salts and nitrogen oxides are expelled converts the magnesium nitrate completely to oxide, and the nitrates of alkalies partly to nitrite. Treatment with cold, dilute ammonium hydroxide dissolves the alkali nitrates and nitrites completely, and the magnesium oxide remains as an insoluble residue. It is dissolved in acid and confirmed in the usual way, with sodium phosphate in ammoniacal solution. The magnesium test is much more sensitive since the precipitation can be made in a volume proportional to the residue observed. Sulfates present a difficulty since magnesium sulfate is not decomposed to oxide short of violent ignition. Oxidation of hydrogen sulfide to sulfates is found not to take place to any objectionable extent, and, therefore, sulfates must be present as such in the original unknown in order to interfere. When 0.2 mg. of any one of the three is present, it can be detected in the presence of large amounts of the other two. A. P. B.

The Preparation of Hydrogen Peroxide. M. L. KILPATRICK, O. M. REIFF AND F. O. RICE. *J. Am. Chem. Soc.*, **48**, 3019–21 (Dec., 1926).—A quantitative study of the preparation of concentrated solutions of hydrogen peroxide. Sodium peroxide and sulfuric acid are used, the method works well in the laboratory, and the yields are good. No difficulty is experienced in obtaining 90 per cent solution. A. P. B.

Further Evidence Concerning the Magnitude of Internal Pressures, Especially That of Mercury. T. W. RICHARDS. *J. Am. Chem. Soc.*, **48**, 3063–81 (Dec., 1926).—Internal pressures, dependent upon the attractive forces of chemical affinity and cohesion, are among the most fundamental properties of matter. Coefficients of expansion and compression, as well as latent heats of evaporation and chemical action, indicate that for compact solids they may attain or exceed 100,000 atmospheres. This paper amplifies equations which have been advanced in previous papers and provides new evidence as to the magnitude of these pressures for monatomic elements by a consideration of the change of compressibility and expansibility with increasing pressure. A new and better supported definition is given for the rate of change of the intrinsic distending pressure with changing volume. The necessity of imagining very great internal pressures to account for observed facts is more than ever emphasized. Values of these pressures are given for 19 elements. A mathematical method

of treatment is advanced which is capable of predicting the behavior of these properties of elements within the limit of experimental error. Calculations are shown for several of the elements. The theory of balanced pressures is further discussed and the paper shown to be in support of it. A. P. B.

Some Considerations in Building Salary Schedules. ARTHUR B. MOEHLMAN. *J. Educ. Res.*, **14**, 256–69 (Nov., 1926).—A discussion based upon principles of economic theory is given in regard to teachers' salaries as considered from the standpoint of skilled labor in relation to the wages of unskilled labor.

Wages are determined by a number of variables of which the cost of living and the social value of the product tend to be dominant. Thus, the problem was to determine whether there is such a relationship between the wages of labor and the salaries of teachers as to establish an index upon which salary schedules may be rather uniformly built, and if so, by means of this index, provide a convenient instrument by which a salary schedule may be quickly arranged in any community.

The questionnaire method was employed and the results compared with data taken from the compilation of Burgess on the wages of skilled and of unskilled labor since 1841, in which it appears that the general relationship of unskilled and skilled labor is as 100 is to 180. Tables are given of the earnings of unskilled and skilled workmen, and those of teachers. From the relationships shown the author has derived hypotheses in regard to teachers' salaries which, when applied to an actual situation, show a close relationship to current, modern practice. The author has prepared an index which may be used to advantage as a basis upon which to build salary schedules. While this index sets up certain definite limits for *average* performance as the present expression of the social value placed upon teachers' service, it is possible, as the future service of the teacher grows in definite social value and is recognized by the community, that the upper limits may be changed, particularly the rewards for special merit. R. M. P.

A Study of Pupil Errors in Chemistry. J. C. BENNETT. *J. Educ. Res.*, **14**, 275–83 (Nov., 1926).—Powers' General Chemistry Test, Form B, was given to 1470 pupils in 24 high schools. Tabulated results are given which show that the median score for this study is 31.5 while the median established by the author of the test is 36. A study was made of the pupil errors found on these test papers with reference to fifteen items in which either the formulas or names of compounds were required. Detailed results are given with a table of comparison of per cents of correct responses on certain questions.

Inspection of the 401 papers scoring above 50 shows that even among the best students the valences of radicals are poorly fixed in mind. Because of the large amounts of subject-matter which the student is expected to master, teachers fail to impress the principles involved and to give the drill which might remedy the difficulty in formula writing. If formula writing is essential, the teacher must be satisfied with nothing less than complete achievement of this skill. We cannot half teach it without wasting almost *all* the time put into it.

In the question which required the naming of an organic compound, CH_3CHO, sixteen incorrect names were written which indicates that the teaching of organic chemistry is not functioning as it should. Otherwise, our pupils would not confuse wood alcohol with glycerin, acetylene, starch, or vinegar, as shown on a large number of the papers. R. M. P.

The Present and Future of the Food Supply. E. B. FORBES. *Ind. Eng. Chem.*, **18**, 1263–7 (Nov., 1926).—The author considers the problem broadly, from both the economic and nutritional viewpoint. He points out the tendency of increasing populations to turn to cereal foods, with their known nutritional defects. The apparent greater efficiency of the dairy cow over the beef animal as a converter of vegetable matter into human food, is pointed out. The manifold relations of chemistry to the entire food industry are discussed under the topical heading, "The Food Supply Becomes a Chemical Enterprise." V. R. T.

Future Chemotherapy. A. S. LOEVENHART. *Ind. Eng. Chem.*, **18**, 1268–72 (Nov., 1926).—L. illustrates the mission of chemotherapy which embodies the united efforts of organic chemistry, pharmacology, and clinical medicine, by describing the campaign against two diseases caused by protozoan organisms, namely syphilis and trypanosomiasis. African sleeping sickness is one form of the latter. Arduous research has produced specifics partially successful in combating these diseases. The startling ravages of the various forms of trypanosomiasis among men and animals in Africa, and their threat in the Americas, are related. The extensiveness of each of the three necessary branches of chemotherapy makes research by individuals or small groups very difficult. The need for a national or international laboratory is emphasized. V. R. T.

From the Educational Times of Seventy-Five Years Ago. A REPRINT. *Educ. Outlook*, **78,** 403 (1926).—The reprint gives a German teacher's view of the English schools in 1851. If it were not for the title one might be led to think that he was reading an article about the schools of 1926. Education problems then were very similar to those now. The German teacher laments the fact that pupils are inattentive and more interested in certain outside-of-school affairs than in academic studies and that school principals are not as efficient as they should be. All this resulted in serious disciplinary problems, for surely the younger generation (1851) were worse than any that had preceded them! Their problems were ours but we do think that today we are facing those problems more intelligently. S. R. P.

Qualities Leading to Appointment as School Supervisors and Administrators. ROBERT H. MORRISON. *Educ. Admin. and Superv.*, **12,** 505–11 (1926).—An investigation to determine why people are appointed to positions as school supervisors and administrators in the state of Colorado. A detailed analysis of traits listed by employers as qualities leading to appointment as supervisors and administrators is given. Character traits of applicants seem to largely determine appointment. Successful teachers do not necessarily make successful supervisors. There is an urgent need that students lacking qualities making for success in supervision and administration be advised against training for such positions. S. R. P.

Successful Placement of Teachers. ALONZO F. MYERS AND EDITH BEECHEL. *Educ. Admin. and Superv.*, **12,** 596–602 (1926).—The Bureau of Appointments of Ohio University, Athens, Ohio, attempts to place the best teachers in positions which pay the highest salaries and the weakest teachers in positions paying the lowest salaries. In determining the probable teaching success of the students the most important single factor used is a student-teacher rating card made out by the critic teachers. At the end of the first semester's teaching experience the superintendent under whom the teaching is being done is asked to rate the individual's teaching ability. Using a rather unique device for obtaining the correlation between the critic teacher's rating and the superintendent's rating, a correlation of + 0.663 was found. This correlation in predicting teaching success is very much higher than the correlation found by Whitney who found a correlation of + 0.238 between critic teacher's rating and superintendent's rating. The Whitney method gave a correlation of + 0.192 in the above investigation. S. R. P.

Improvement of Teachers in Service. FRANK BALLOU. *Am. Educ. Digest*, **46,** 149 (Dec., 1926).—A study of the cross section of the teaching profession in any one of the larger communities will reveal the fact that many experienced teachers were prepared when educational standards in teacher-training institutions were far lower than they are today. The scientific movement in public school education has worked revolutions in educational practice such that all teachers who have not kept in step need to use means of improvement.

As such means are suggested: educational journals, new books, extension courses, teachers' meetings, demonstration schools, and provision for leaves of absence for study and travel.

The obligation of the teacher to keep herself qualified to render increasingly effective service is no greater than the obligation of the public to reward adequately such improvement. The public should provide a satisfactory salary schedule, possibilities of additional reward for increased preparation and unusual teaching accomplishments, security of position during efficient service, and a satisfactory retiring annuity in case of old age or disability. There should also be provided a well-trained, experienced, and forward-looking supervisor to whom every teacher should be able to look for helpful advice, profitable suggestions, and inspiration for the improvement of her work. J. W. HOWARD

Visual Instruction and Classroom Instruction. R. H. JORDON. *Am. Educ. Digest*, **46,** 156 (Dec., 1926).—In order for American education to meet even the social and civic aims it must teach pupils to reflect, weigh evidence, form judgments, and really think. In order to think one must have the materials at hand on which the reflective process is based. The clearer and more concrete these are the clearer and more definite will the abstract thought process become.

There is a group which believes visual instruction does not strengthen impressions in the same way as oral drill and printed page. This is just another form of the conflict between the theory of interest and the theory of effort. Both theories really have a place, however, interest acting as a stimulus to effort. Interest should not be confused with entertainment.

One is more than justified in using all forms of illustration which will make clear

and well understood the materials of the text. The modern trend is away from "lesson learning" in favor of teaching the individual pupil to comprehend the subject-matter as his own. In order to do this the student must get the proper "mental image." In this visual aids are especially helpful.

Visual aids may also help eliminate the waste of time and effort in lengthy and involved presentations.

A picture should not be used to illustrate natural phenomena if the actual object can be presented to the class. J. W. HOWARD

Training Classes to Make Use of Trade Magazines. EDITORIAL STAFF REPORT. *Am. Food. J.*, **21,** 527 (Nov., 1926).—First of a series of discussions on trade papers as teaching helps. The following are cited as specific examples:

The Northwest Miller for Sept. 1, 1926, contains articles on farmers' problems and food values which, in the hands of a clever teacher, can be made to assume important places in the year's teaching plans.

A paper by I. T. Miller in Aug., 1926, *Baking Technology*, on "Artificial Color in Cakes" is suited to class-project work.

The *National Grocers Bulletin* for July, 1926, discusses their emblem in such a way that it could be made the basis for student reports on such topics as "What a progressive grocer can accomplish for the nutrition of the neighborhood" and "Possible harm done by a non-progressive or non-ethical grocer." J. W. HOWARD

Giant Power: An Interpretation. MORRIS LLEWELLYN COOKE. *Atlantic Mo.*, **138,** 813–22 (Dec., 1926).—A differentiation is made between "giant power" and "super power" in that the latter is a network of wires interconnecting small or moderately sized plants, most of which are situated in centers of population, while the former consists of great generating plants situated not in cities but at or near the mines. If all the potential water power of the country were now developed it would not support our present energy demand. C., therefore, believes it necessary to develop electric power from coal and thinks this can be done most efficiently by great power plants at the mines. Low-grade coals could be used, of which the coal fields of Pennsylvania alone are capable of supplying scores of times the power of Niagara continuously for 500 to 1000 years. If mine-mouth stations are developed, the low-temperature processing of coal for the recovery of valuable by-products in connection with the power stations would be profitable and essential to cheap current. This would include by-product coke ovens for the recovery of $(NH_4)_2SO_4$, gas, tar, and oils that are now wasted in smoke. More than 4000 commercial products are already derived from the pretreatment of coal, ranging from medicines and perfumes to fertilizers and motor fuels. G. W. S.

The Training of the Chemist. P. WALDEN. *Z. angew. Chem.*, **39,** 969 (Aug. 19, 1926).—Discusses the revision of current chemical instruction which is necessary in view of the increasing number of present problems and of possible future developments.

The author recommends that the general scientific training of the German chemist should include more physics and physico-chemical theory and technic; and that all chemists should know some biological chemistry. In this connection he points to the steadily increasing volume of biochemical research. In 1925 publication of original work in the various branches of the science was distributed in the following proportions: inorganic 10 per cent, pure organic 20 per cent, general and physical 130 per cent, biochemistry 40 per cent.

The paper contains an interesting comparison of research in Germany and in America. It seems that, measured by the number of pages printed, Germany's production is double that of the U. S., although the latter has twice as many chemists. DAVID WATSON

Some Aspects of Physico-Chemical Education. H. G. GRIMM. *Z. angew. Chem.*, **39,** 979 (Aug. 19, 1926).—The training of the German chemist in physical chemistry is, in the author's opinion, inadequate. The teaching staffs and equipment allocated to this in the "Hochschule" and in the University are insufficient while the teacher in many cases does not have the desirable amount of freedom. The period of instruction in physical chemistry (2–6 weeks) is fifteen to thirty times smaller than that available in organic or inorganic and bears no reasonable relation to the difficulty of the subject-matter. This lack of balance is reflected in the topics chosen for doctor's dissertations.

The student of chemistry, who is going to do original work, must get a sounder preparation in mathematical and physical theory and practice and be made to feel *at the start* the importance of these for his own science. To this end Grimm advises that lectures on mathematics for chemists should supplement the regular course and

that the introductory laboratory course in general chemistry should be directed by an assistant with a good physico-chemical training.

Note: The same number of this journal contains further articles by Biltz, Berl, Kertess, and Böttger on chemical education in Germany. DAVID WATSON

The Molecular Weight of Egg Albumin. I. In Electrolyte-Free Condition. THE SVEDBERG AND J. B. NICHOLS. *J. Am. Chem. Soc.*, **48**, 3081–93 (Dec., 1926).—Until very recently osmotic pressure measurements have provided the most reliable data for calculating the molecular weights of the proteins, although these data in themselves are rendered uncertain by effects arising from the Donnal membrane equilibria and other causes. A method for determining the molecular weights of proteins which is free of all membrane complications has been developed and described by author S. It depends upon establishing equilibrium between the centrifuging and diffusion of the material as the result of prolonged centrifuging at constant temperature. This method is here applied for the first time to a colorless protein. Results obtained show that in egg albumin of only moderate impurity there was present a small amount of some material of molecular weight, approximately 170,000. Further purification to remove this material gave an egg albumin which is shown to be a uniform substance of molecular weight 34,500 ± 1000 in electrolyte-free solution. A. P. B.

The Composition of Hydrochloric Acid of Constant Boiling Point. W. D. BONNER AND B. F. BRANTING. *J. Am. Chem. Soc.*, **48**, 3093–5 (Dec., 1926).—A redetermination of the composition of constant-boiling HCl under conditions where the average barometric pressure is 640 mm. The technic used is described in detail and tables of results are shown. Of interest is the fact that the slope of the curve covering a difference of 40 mm. pressure in the range used by the authors is markedly different from the slopes of curves obtained by other investigators working at different pressures. This indicates that the composition of the acid is not a linear function of the distillation pressure and demands investigation over a wide pressure range. This will be undertaken by the authors during the coming year. A. P. B.

A Revision of the Atomic Weight of Titanium. The Analysis of Titanium Tetrachloride. II. G. P. BAXTER AND A. Q. BUTLER. *J. Am. Chem. Soc.*, **48**, 3117–22 (Dec., 1926).—Baxter and Fertig have described a method for the purification and analysis of a specimen of titanium tetrachloride. The atomic weight which they found was 47.9, lower than the usually accepted value of 48.1 obtained by Thorpe. Accordingly analysis of the fractions of the tetrachloride previously prepared have been continued and the same value of 47.90 is obtained on the basis of Cl = 35.458. The paper describes the various refinements of procedure characteristic of atomic weight work and several tables of data are included. A. P. B.

Properties of Thin Films. W. B. HARDY. *Nature*, **118**, 700–1 (Nov. 13, 1926).—A discussion on films emphasizing that we are dealing with a fourth state of matter. Choose what physical constant we may it will have a different value for any particular kind of matter in this state from what it has in any of those other states which are more easily apprehended by the senses. The article points out that life depends on this fourth state, there being a film over the surface of each living cell; but deals primarily with the effect of oil on causing seas to enter a "smooth." H. K. M.

The Structure of Catalytically Active Copper. F. H. CONSTABLE. *Nature*, **118**, 730 (Nov. 20, 1926).—The nature of the change that occurs on the activation of a metallic catalyst by alternate oxidation and reduction, or by continued use and the change that occurs during sintering has been an open question. The observations for the activation of a catalyst present experimental difficulties but seem to indicate that the increase in area of the supported copper films on successive reduction is not large. The nature of the surface alters considerably since the linear rate of oxidation increases markedly. In case of sintering the observations can be made with accuracy, the nature of the surface is changed since the linear rate of oxidation falls and the increase in surface area is marked. Continued exposure to high temperature causes area to diminish to a definite limit for each temperature. Not only is there an area change during activation and sintering but also an unmistakable change in the nature of the surface. H. K. M.

Application of the Drop Weight Method to the Determination of the Surface Tension of Colloidal Solutions. W. D. HARKINS. *Nature*, **118**, 732–3 (Nov. 20, 1926).—The method has been improved so that the precision is to within a few hundredths of one per cent. The number of drops used may be reduced and in much work on colloid solutions only one drop needs be allowed to fall in the final determination. Work is underway to reduce the error of the ring method. H. K. M.

Active Nitrogen. E. J. B. WILLEY. *Nature*, **118**, 735 (Nov. 20, 1926).—Calcu-

lations from data obtained by introducing into the afterglow a number of gases, and by the action on fine filaments, show that the energy of active nitrogen is *ca*45,000 cal. per gram mol. The decay of the afterglow has been measured by optical methods and the process is in all probability bimolecular with respect to active nitrogen but termolecular in reality since the total pressure appears to exert a marked influence. The work of Ludlam and Easson and that of Saha and Sur are discussed. H. K. M.

University Laboratories and Research. J. J. THOMSON. *Nature*, **118,** 772–3 (Nov. 27, 1926).—From an address delivered at the opening of the new science laboratories at the University College of North Wales, Bangor, on November 2nd. H. K. M.

The Function of Chlorophyll. ANON. *Nature*, **118,** 786–7 (Nov. 27, 1926).—Stern has provided experimental grounds for the conclusion that chlorophyll, as present in the living plant, is fluorescent. Noack's investigations concern themselves directly with the photo-oxidative effects produced by fluorescent pigments. The toxic action of sunlight on leaves in the absence of carbon dioxide is explained as a photodynamic effect of the fluorescent pigment upon the surrounding protoplasm produced in the absence of carbon dioxide. The carotinoids were bleached by photo-oxidation in sunlight in less than an hour in the presence of chlorophyll (1 in 100,000); without this trace of chlorophyll they remained unaltered after six hours' exposure. Stern explains chlorophyll fluorescence as due to its solution in lipoids, but Noack finds that dry leaf tissue, from which lipoids and carotinoids have been removed by 24 hours' extraction with petrol ether, still retains its chlorophyll and still show the photo-oxidation of benzidin and bleach as the result of photo-oxidation. The theoretical interpretation is still far from clear, but it seems well worth consideration as suggesting yet another line of experimental approach to a very fundamental problem, the function of chlorophyll. H. K. M.

Geneva Protocol Should Be Defeated. EDITORIAL. *Chem. & Met. Eng.*, **33,** 658 (Nov., 1926).—Condemning the protocol, which is designed to forbid all forms of chemical warfare, as being a proposal which ignores the truth, risks impractical and unbearable international meddling with our chemical industry, threatens the existence of a vital defense, the Chemical Warfare Service, and is withal a "futile gesture," the editor calls upon the chemical industry to be heard against its ratification by the Senate during the first session of 1926. The bill has already passed the Committee on Foreign Relations. The unanimous opinion of all qualified authorities that men wounded by gas are less likely to die or remain permanently disabled than those hurt by other arms, is pointed out, as well as the probability that any nation fighting for its existence will not hesitate to use arms forbidden by treaties. V. R. T.

The Activation of Molecular Hydrogen by Electron Impact. GEORGE GLOCKLER. *Science*, **64,** 506–7 (Nov. 19, 1926).—The activated hydrogen was allowed to react with copper oxide in a four-electrode tube. The resulting water was frozen out and the decrease in pressure measured. A sharp decrease in pressure occurred when electrons of 11.4 volts energy impinged on hydrogen molecules. A kink in the current-potential curves occurred at the same voltage. Latest spectroscopic results give for the hydrogen molecule a resonance potential of 11.6 volts. G. H. W.

Titles of Papers Presented at the Autumn Meeting of the National Academy of Sciences, Philadelphia, Nov. 8 and 9, 1926. *Science*, **64,** 506–10, 530–2 (Nov. 19, 1926).—New proofs of solar variation, C. G. Abbot. Forty years of Blue Hill Observatory: Precipitation, E. B. Wilson. A Pneumatic-drive method for measuring fatigue of metals at high frequencies, L. J. Briggs and D. H. Strother. Note on the thermodynamics and kinetics of gaseous explosive reactions, F. W. Stevens. Luminescence due to radio-activity, D. H. Kabakjian. Recent measurements of the velocity of light, A. A. Michelson. Transformations of manifolds, S. Lefschetz. The density of oxygen and its compressibility below one atmosphere, G. P. Baxter and H. W. Starkweather. The density, compressibility, and atomic weight of nitrogen, G. P. Baxter and H. W. Starkweather. The apparition dates of the Andromede or (Bielid) meteor swarms, Willard G. Fisher. A decade of eclipse observations, John A. Miller. The method of dependencies for solving equations, with an application to photographic positions of asteroids, etc., Frank Schlesinger. Family traits as determined by heredity and environment, Franz Boas. Some physical characteristics of the American negro population, Melville J. Herskovits, Elden Pueblo, and J. Walter Fewkes. A Pliocene bear from Oregon, John C. Merriam and Chester Stock. The embryology of Amphioxus and the equipotential theory of development, Edwin G. Conklin. An experimental study of organization in the egg, D. H. Tennent. General principles of the relation between growth and behavior in vertebrates, G. E. Coghill. Mammalian growth curves, C. B. Davenport. The synthesis of isomers of proflavine and of neutral

acriflavine, M. T. Bogert and P. G. I. Lauffer. The electrolytic dissociation of water in salt solutions, Herbert S. Harned. Fluogermanates of the univalent metals, John H. Muller. Observations on the nature of ossification, W. G. MacCallum. Epidemic encephalitis and simple herpes, Simon Flexner. The death rate from diphtheria in Massachusetts for 51 years, 1875–1925, Carl R. Doering. Thyroid and parathyroid in the chemical differentiation of bone, Frederick S. Hammett. The permeability of mammalian erythrocytes and certain other cells to ammonium salts, M. H. Jacobs. Quantitative potentiometric measurements on intra-cellular p_H values of single fundulus egg cells, J. H. Bodine. Suggestions regarding photoplasmic surfaces, W. J. V. Osterhout. The physical properties of erythrocytes, William Seifriz. G. H. W.

The Configurational Relationship of Dextro-Methylethyl Carbinol to Dextro-Lactic Acid. P. A. LEVENE, A. WALTI, AND H. L. HALLER. *Science*, **64,** 558 (Dec. 3, 1926).—Dextro-methylethyl carbinol and dextro-lactic acid have been correlated and found to belong to the same series, *i. e.*, the *l* series of hydroxy acids. G. H. W.

Poisoning by Mercury Vapor. L. M. DENNIS. *Ind. Eng. Chem.*, **18,** 1205 (Nov., 1926).—Dennis summarizes the results of an investigation by Prof. Stock, of Berlin, on the toxic effects of mercury vapor. Stock suffered for years a decline in health, which the best physicians could not diagnose. Appearance of his symptoms in more violent form, upon two assistants working with mercury in a closed room, led him to investigate the poisonous properties of the vapor. Air in his laboratory contained from 0.01 to 0.001 mg. of mercury per cubic meter. Air saturated with the vapor at room temperature contains 12 mg. per cubic meter. He states that mercury inhaled is retained by the lungs, and that only time and fresh air can remove it. It is suggested that the sufferings of Faraday during his latter years were very probably due to this cause. The importance of proper precautions against mercury being left exposed to the air in rooms is evident. V. R. T.

Nutrition and Health. H. C. SHERMAN. *Ind. Eng. Chem.*, **18,** 1261–3 (Dec., 1926).—S. summarizes the results of nutritional research, to date, in non-technical style. Milled grain products are deficient in calcium, phosphorus, iron, and the vitamins. Whole grains would partially supply this lack in regard to phosphorus, iron, and vitamin B, but will not furnish calcium, which is of major importance, nor the fat-soluble vitamins. As nutritional sources of the latter, milk, fruits, and vegetables are recommended as superior to meats and fish. The short life cycle of the rats which furnish the experimental data has started investigations of racial as well as individual nutrition, which may have important human application. V. R. T.

Future Trends in Industrial and Engineering Chemistry. VARIOUS AUTHORS. *Ind. Eng. Chem.*, **18,** 1009–41 (Oct., 1926).—Ten papers, each by recognized authorities, discuss the probable developments in the following fields: Automotive fuels, low-temperature carbonization of coal, light metals, petroleum, iron and steel, ceramics including cement, synthetic organic chemistry, electrochemistry, cellulose, and soil conservation. To completely abstract each would not be feasible, so that only the first is outlined, and indicates the completeness of the others. It is pointed out that improvement may be expected in recovery of petroleum from the sands, in refining, and in burning, so as to make the supply of this fuel go farther. The probable substitutes are: Alcohols from the fermentation of vegetable matter, shale oil, oils from the low-temperature coking of coal, oils from hydrogenation of coal, and alcohols, hydrocarbons, and other organic compounds synthesized from carbon monoxide and hydrogen. V. R. T.

Our Future Sources of Energy. H. L. DOHERTY. *Ind. Eng. Chem.*, **18,** 1062–4 (Oct., 1926).—The author warns sharply against any tendency to quit present research toward the efficient utilization of energy, in view of future sources which may or may not turn up. The point is emphasized that the great natural tendency is for energy to seek its lowest level, and that our problem is to most efficiently utilize that inevitable flow, for the processes of civilization. V. R. T.

Progress of a Year—A Chemical Review. D. H. KILLEFFER. *Ind. Eng. Chem.*, **18,** 1041–6 (Oct., 1926).—K. prefaces his discussion by noting the rapidly expanding public interest in systematic scientific research which has resulted in the establishment during the year of tremendous research endowments. These are the $500,000 five-year appropriation by the petroleum industry; and the proposed $20,000,000 program of the National Academy of Sciences, of which $3,000,000 has been raised. A third is presaged by the Senate bill providing for the creation of a National Institute of Health. The topics of the article are: Important meetings, progress of pure science, industrial progress, political aspects, tetraethyl lead, petroleum as a raw material rather than a fuel, legal aspects, industrial alcohols, and chemical warfare. V. R. T.

A Look Ahead. JAMES F. NORRIS. *Ind. Eng. Chem.*, **18,** 994–8 (Oct., 1926).

—While warning that the exact prediction of scientific development is difficult, N. pleads for freedom of the imagination as necessary and permissible for continued progress. He believes that utilization of atomic energy is not impossible. He predicts the discovery of new and better specifics for various widespread diseases, and the application of energy relationships to the solution of problems in organic chemistry. Further financial support is anticipated for the three types of research: First, purely scientific with no commercial end in view; second, industrial research in systematized plant development; and third, a combination of the first two in the more rapid application of the discoveries of pure science to industry. V. R. T.

The Importance of Rubber in Modern Civilization. EDWIN E. SLOSSON. *Ind. Eng. Chem.*, **18,** 1104–8 (Nov., 1926).—In characteristic popular and entertaining style Dr. Slosson discusses the political and scientific aspects of the international rubber situation. V. R. T.

Artificial Rubber during the War in Germany. C. C. BURGDORF. *Ind. Eng. Chem.*, **18,** 1172–3 (Nov., 1926).—The author, writing evidently from personal experience, outlines the process employed. Starting with coal and limestones, the successive steps involved the preparation of calcium carbide, acetylene, acetaldehyde, acetic acid, acetone, pinacol, and finally dimethylbutadiene. Polymerization of the latter gave rubber-like material. The product was inferior to the natural material when worked up as soft rubber, but was satisfactory for use as hard rubber. V. R. T.

Cellulose Sausage Casings. W. F. HENDERSON AND H. E. DIETRICH. *Ind. Eng. Chem.*, **18,** 1190–3 (Nov., 1926).—Animal intestines, the material chiefly used at present for sausage casings, are unsatisfactory for both sanitary and technical reasons. A fellowship was, therefore, established in 1916 at the Mellon Institute to devise a synthetic casing. A suitable one has recently been produced and a plant for manufacturing them is now being constructed. The synthetic skins are made from cotton linters by special manipulation of the viscose process, involving solution in sodium hydroxide, exposure to the fumes of carbon disulfide, "ripening" of the gelatinous mass, and molding of the skins. V. R. T.

Through the Chemist's Looking-Glass. JAMES F. NORRIS. *Tech. Rev.*, **29,** 22–6 (Nov., 1926).—An abridgment of the address given by Dr. Norris at the Jubilee Meeting of the A. C. S. in Philadelphia, September, 1926.

An interesting review, with illustrations of wonderful growth of chemistry and chemical equipment since Priestley's time. S. W. H.

Cathode Tubes. EDITORIAL. *Tech. Rev.*, **29,** 90 (Dec., 1926).—Placed in their path, rats die, shrivel up; acetylene gas solidifies; wax is given a permanent electric charge; castor oil becomes solid; insects and germs die instantly; calcite glows with a cold yellow light.

The Coolidge tube uses 350,000 volts and the rays, of greater intensity than would be produced by a ton of radium (worth one hundred billion dollars) leave the tube through an aluminum foil window five-ten-thousandths of an inch thick, capable of withstanding 50 lb. pressure. The rays are electrons.

Its practical use is still in the conjectural stage. It cannot be a death-ray tube, as earliest popular accounts suggested for its effective range is only a few yards, but battlers against cancer can see possibilities. S. W. H.

Talking on Light Rays. *Tech. Rev.*, **28,** 375 (May, 1926).—The work of Donald C. Stockbarger, in transmitting the spoken word on a beam of invisible ultra-violet light, is described.

Mr. Stockbarger's, apparatus has two important features: (1) It is perfectly directed, no one outside the light (or ultra-violet) path could receive the message. (2) The entire operation of transmission can be concealed, since invisible ultra-violet radiations can be used instead of light wave-length. S. W. H.

The College and the Secondary Schools. ALFRED E. STEARNS. *Harvard Alumni Bull.*, **28,** 750–3 (March 26, 1926).—A very interesting talk given at the Harvard Club, Boston.

The tenor of Dr. Stearns' talk is given as follows:

"One of the criticisms against the colleges is that they are striving to do altogether too much along the line of the purely intellectual in the instruction they are giving, and that the character or the all-around development of the boy is considered purely a by-product—something that can safely be ignored, provided his mind is stimulated and his intellectual life and talents developed to the full."

This is an unquestionably dangerous idea. S. W. H.

The Faculty Committee on Admission. HENRY PENNYPACKER. *Harvard Alumni Bull.*, **28,** 835–7 (April 15, 1926).—The college is a beneficiary institution for it is

granting to the selected boy a substantial sum of money, since the boy pays but $300 a year for what it costs the college $800 to give him.

What we ask of a boy coming to college is, first of all, character and, second, power. Harvard, beginning 1926, sets a limitation of 1000 upon the number admitted to the freshman class. Limitation means selection.

We are looking for the all-around boy. S. W. H.

Classifying the Stars. ANNIE J. CANNON. *Harvard Alumni Bull.*, **28,** 565–8 (Feb. 11, 1926).—An inspiring radio talk by a famous woman astronomer, Dr. Annie J. Cannon of Harvard Observatory. The following few sentences of this four-page article may interest chemists: "Classifying the stars has helped materially in all studying of the structure of the universe. No greater problem is presented to the human mind. Teaching man his relatively small sphere in creation, it also encourages him by its lessons of the unity of Nature and shows him that his power of comprehension allies him with the great intelligence over-reaching all." S. W. H.

Habits of Study. EDITORIAL. *Harvard Alumni Bull.*, **28,** 529–30 (Feb. 4, 1926).—As to the methods of study, the records show that students are largely innocent of the knowledge of the different requirements of different tasks. They seldom think out cases, problems, exceptions, contrary positions, applications, or corollaries. Instruction in study is needed and specific directions for particular pieces of work.

There is great and unnecessary waste of time in college work. Much of it could be prevented by more careful attention on the part of instructors to the problems of teaching as such—not merely to modes of presentation in class, but to the *guidance of individuals* in their learning. S. W. H.

Light Shining on Mineral Produces Electric Current. A piece of the mineral, molybdenite, one of the chief sources of the metal molybdenum, used in steel manufacture, may replace the fragile photoelectric cell in some forms of scientific work, Dr. W. W. Coblentz, of the U. S. Bureau of Standards, told the American Astronomical Society, in session at Philadelphia recently.

Dr. Coblentz has been studying the actino-electric effect of molybdenite, the property that causes it to convert light energy falling on it into electrical energy. Previously he found that pieces of the mineral have closely adjacent spots which generate either positive or negative electricity. The result is that when the whole crystal is exposed to light the positive and negative currents neutralize each other, and very little effect is noted, but if a single one of the spots is selected and illuminated, a current is produced of sufficient intensity to be indicated with a galvanometer.

Very recently, however, Dr. Coblentz told the society, he has found crystals in which all of the sensitive spots give the same kind of electricity, either positive or negative. When one of these crystals is completely illuminated, a considerable current, as compared with the others, is produced. By using vacuum tube amplifiers, such as are used in radio, the current may be magnified greatly and the crystal made available as a delicate detector of light.

Such a crystal is sensitive to the visible light waves and to the infra-red, or heat waves, which are similar, but vibrating too slowly to be visible.—*Science Service*

Finds Economical Method for Getting Turpentine. The producers of yellow pine lumber in the South need no longer regard the producers of turpentine and rosin as enemies destroying the best part of their trees. A new method of extracting the valuable oleoresin "gum" which is the basis of naval stores conserves nearly two-thirds of the wood hitherto wasted through damage caused by the long scars made on the pines near their bases. This was described by Dr. Eloise Gerry of the U. S. Forest Products Laboratory at Madison, Wis., speaking before the American Botanical Society. Dr. Gerry, who has just returned from a tour of conferences with the naval stores producers in Mississippi, Georgia, and Florida, stated that the new method obtained a better yield of gum from a nine-inch scar than the old was able to realize from a scar 23 inches long.—*Science Service*

Local Activities and Opportunities

University of Minnesota. Dr. S. C. Lind, formerly Chief Chemist of the Bureau of Mines and later Associate Director of the Fixed Nitrogen Research Laboratory of the Department of Agriculture, has been appointed professor of chemistry and director of the school of chemistry. Dr. Lind will give graduate work in Photo- and Radio-Active Chemistry.

Dr. G. Glockler is working with Dr. Lind on the chemical effect of electrical discharges in gaseous hydrocarbons. He is a Fellow of the National Petroleum Institute.

B. F. Ruth, of Michigan State College, is a new instructor in the chemical engineering department.

Four student chemical organizations, Iota Sigma Pi, Pi Delta Nu, Alpha Chi Sigma and Phi Lambda Upsilon are sponsoring a series of popular lectures on subjects allied to chemistry. The first of the lectures was given Dec. 1st by Dr. S. C. Lind. His topic was "Helium, Its Discovery and Commercial Applications." The second lecture was "Chemistry in Bacteriology," by Dr. W. P. Larson of the department of bacteriology. This lecture was given on Jan. 12th.

The program of the chemistry and Physics division of the annual state convention of the Minnesota Educational Association included addresses by the University on:

"Investigations in Teaching Science," by Dean E. M. Haggerty.

"What Is the Best Preparation in High School for College Physics," by A. Zeleny.

"Ideal Preparation of Students for College Chemistry," by G. B. Heisig.

"Anatomy of the Atom," by F. H. MacDougall.

"Molecular Architecture," by W. H. Hunter.

"A Demonstration in Glass Blowing," by H. N. Stephens.

Drs. G. H. Montillon and L. H. Reyerson have been made associate professors, and Drs. A. E. Stoppel and H. N. Stephens have been made assistant professors.

Eastern New York Section, A. C. S. At a meeting of the Eastern New York Section of the American Chemical Society, held December 10th, the following officers were elected:

Chairman: Thomas A. Wilson, Union College, Schenectady; *Vice-Chairman:* Barnard S. Bronson, State College for Teachers, Albany; *Secretary:* E. E. Charlton, General Electric Company; *Treasurer:* A. J. Sherburne, General Electric Company; *Councilors:* Dean E. Ellery and A. W. Davison; *Executive Committee:* J. W. Kern, B. S. Van Klooster and G. M. J. Mackay.

Pennsylvania State College. Mr. Victor Cofman of the Research Laboratory of Armour and Company, of Chicago, gave a series of five lectures on Colloid Dynamics, January 10th–14th, in the physics lecture room of the School of Chemistry and Physics at the Pennsylvania State College. The following is a brief summary of the lectures:

I. The meaning of the word "colloid." The ideal colloid and the factors which govern its physical changes.

The pressure of colloids; the surface pressure of adsorbed substances; the "osmotic" pressure (pressure of swelling) of gels.

The volume of colloids; the thickness of the surface region.

The "temperature" of colloids; the change in surface tension with p_H. The electro-chemical potential and the H-ion concentration.

II. Spontaneous dispersion; the transformation of chemical into surface energy.
Emulsions and the factors that influence them.
Electrical dispersion; the transformation of electrical into surface energy.
The two types of electrical potentials at phase boundaries and their relation to surface phenomena.

III. Surface solutions and thin films; the gas laws in surface solutions and colloids. The Gibbs and other adsorption formulas as special cases of a simple general relation. The velocity of adsorption.

IV. Physiological applications:
Muscular action and its dependence upon "surface" forces. The muscle as a colloid engine working at constant heat temperature.
Nerve conduction: The propagation of disturbances in colloid media.

V. The new colloid concepts and classical thermodynamics.

Many individuals who were interested in special problems had personal interviews with Mr. Cofman, which were very helpful. One of the outstanding impressions gained from the lectures is that colloid chemistry in many of its aspects may well be considered from the energy point of view.

M. C. C. T. A. The fifth semi-annual meeting of the Michigan College Chemistry Teachers' Association was held at Ann Arbor on January 22nd. The program included the following papers: "Our Educational System of Today," by A. L. Ferguson; "The Scope of Colloid Chemistry," by F. E. Bartell; "Correlation of Laboratory and Class Work in General Chemistry," by A. J. Clark, discussion lead by Prof. Van Zyle; "Administration of Laboratory Work in General Chemistry," by L. E. Smith, discussion lead by Miss Dorothy Engle; "A Critical Study and Comparison of Laboratory Manuals," by O. E. Madison, discussion lead by A. I. Beebe; "The Cost of Operating a Laboratory," by R. J. Carney, discussion lead by D. E. Spieth.

Ohio State University. The Seventh Annual Educational Conference sponsored by the Ohio State University, will be held at that institution on April 7, 8, and 9, 1927. As in former years the general sessions will be held on Thursday evening, Friday evening, and Saturday morning. Men of national note, such as Professor E. L. Thorndike, of Teachers' College, Columbia University, Professor Wallace W. Atwood of Clarke University, Judge Olson of the Juvenile Court of Chicago, Payson Smith, Commissioner of Education for Massachusetts, and others, will address the general sessions.

Both forenoon and afternoon of Friday will be given over to sectional meetings of which this year there will be more than thirty. Here again specialists in their fields will contribute as, for example, Professor S. A. Courtis of Michigan, in the Educational and Intelligence Test Section; Professor S. A. Leonard of Wisconsin, in English; Professor Hill of Illinois, in Non-Biological Science, etc.

The keynote of this year's conference is "Expertness in Teaching" and the whole program, both general and sectional, will center around this idea. The uniform testimony of the thousands who have attended past conferences is that each year the conference is outstanding for its helpfulness, its abundance of ideas and its lack of mere talk. There is every reason to believe that this year's program equals, if it does not exceed, all former ones.

The Peoples' Institute, New York City. The following series of lectures is being given at Manhattan Trade School, Twenty-Second Street and Lexington Avenue, New York City. Wednesday evenings, February 9 to March 23, 1926, at eight o'clock. Single admission 25 cents. Course tickets at reduced rates.

Feb. 9—"Chemistry, Old and New," Dr. Harrison E. Howe, Editor *Industrial and Engineering Chemistry*, Washington, D. C.

Feb. 16—"Our Knowledge of Living Matter," Dr. Robert Chambers, Professor Microscopic Anatomy, Cornell University Medical School, New York City.

Feb. 23—"The Life of Plants," Dr. C. Stuart Gager, Director Brooklyn Botanic Garden, Brooklyn, N. Y.

Mar. 2—"The Adjustments of the Human Body," Dr. Lawrence J. Henderson, Professor of Physiology, Harvard University, Cambridge, Mass.

Mar. 9—"The Chemistry of the Human Body," Dr. Carl P. Sherwin, Professor of Physiological Chemistry, Fordham University, New York City.

Mar. 16—"The Nervous System," Dr. Louis Casamajor, Professor of Neurology, Columbia University, New York City.

Mar. 23—"How the Investigator's Mind Works," Dr. William E. Ritter, President, Board of Trustees, Science Service, Washington, D. C.

University of Florida. Florida Chapter of Gamma Sigma Epsilon chemical fraternity held its first initiation of the college year on January 17th. The following men were received as new members: Professors R. C. Goodwin and F. A. Gilfillan, Instructors H. E. Stuhr and L. D. Fonda, and students Webster Merritt and J. Y. Blake.

The College of Pharmacy announces June 3rd–4th as dates for the annual competitive examination for the Groover-Stewart Scholarship. The scholarship pays $1000 over a period of three years and is awarded annually to that graduate of an accredited senior-high school of Florida, making the highest average on the competitive examination.

Mr. L. M. Chew has been declared the winner of the W. D. Jones medal, awarded annually to that graduate of the College of Pharmacy who has an average of 90 per cent and who succeeds in passing the state board with a like average.

University of Chicago. Professor F. Paneth, of the department of physical chemistry of the University of Berlin, lectured in Kent Chemical Laboratory on Friday, February 11th, on "Recent Work on Hydrogen and Its Derivatives." Professor Paneth reported a few months ago that he had succeeded in converting hydrogen into helium; if this is confirmed by further experimentation it would be of enormous possibilities and importance.

Professor J. N. Bronsted, of the University of Copenhagen, lectured in Kent Chemical Laboratory on February 17th and 18th. The subjects of the lectures were: "The Theory of Velocity of Ionic Reactions," and "The Metal Amines and Their Significance for the Physical Chemistry of Solutions."

Professor H. I. Schlesinger spent two weeks in December visiting leading universities in the East in order to study the newest ideas in the matter of construction of chemical laboratories. He is now engaged in the drawing up of specifications for the George Herbert Jones Chemical Laboratory.

At a meeting of Kappa Mu Sigma, women's graduate chemical sorority, which was held on January 18th, twelve candidates were formally initiated into the sorority.

Bernard C. Mortimer received the doctorate degree at the December convocation.

University of Arizona. Notification has been received by the University of Arizona from Edward Ellery, Secretary of the National Society of Sigma Xi, that a charter for the establishment of a chapter was granted at the Convention held at Philadelphia in December. Arrangements are being made for the installation early in April.

On December 10th, J. F. Brezeale, biochemist of the U. S. Geological Survey and associate in chemistry in the Arizona Agricultural Experiment Station, gave an address before the Arizona Section of the A. C. S. The subject was: "Alkali Tolerance in Plants Considered as a Phenomenon of Adaptation."

Phi Lambda Upsilon initiated the following on the evening of December 7th: Morgan Mason, A. J. Eickhoff, J. A. Austin, and T. C. Hudspeth.

On December 14th, R. F. Blount, instructor in biology, addressed the Sigma Xi Society on the subject: "Seasonal Changes in the Interstitial Cells of the Testis of the Horned Toad."

Dr. F. N. Guild, professor of geology, addressed the Arizona Section of the A. C. S., January 14th, on the topic: "Optical Methods in the Identification of Pure Chemical Compounds."

College of the City of Detroit. The department of chemistry and chemical engineering of the College of the City of Detroit is offering a program of lectures on various phases of chemical engineering through the coöperation of the Association of Chemical Equipment Manufacturers. The program is as follows: January 12th, "Oxy-Acetylene Welding in Chemical Plant Construction," by W. B. Miller; January 19th, "Industrial Heating by Oil Circulation," by A. B. McKechnie; February 2nd, "Hydraulic Separation and Concentration with the Fahrenwald Sizer," by W. C. Weber; February 15th, "Glass as an Industrial Material," by A. E. Marshall; March 2nd, "Pumping Equipment for the Chemical Industry," by E. A. Suverkrop; March 9th, "Filtration Equipment in Today's Industries," by C. B. Oliver; March 16th, "Electrical Power in the Chemical Industry and in Chemical Processes," by J. H. Livsey.

P. S. E. A. The Science Section of the Pennsylvania State Education Association served a science dinner, cafeteria style, at the William Penn High School at Harrisburg on December 29th. This dinner was one of the first steps in the organization of a state science association. Speeches were made by a number of the members: First, on the plan and, second, on the best methods of organization and procedure necessary to effect the same. It was unanimously voiced that there was a specific need for a strong state science association made up of units corresponding to the convention districts with these units united and centralized into a state organization, the meetings of which would be held in conjunction with the P. S. E. A. It was voted to have a committee of seven, one from each of the present convention districts of Pennsylvania, appointed by the president of the Section to perfect such an organization.

C. A. Gorgas of Peabody High School, president of the Langley Association of Science Teachers, pledged the loyal support and active coöperation of that association in the movement. Professor Gerald L. Wendt, Dean of the School of Chemistry and Physics, Pennsylvania State College, and Chairman of the Pennsylvania State Essay Committee, gave a brief talk on the importance of the participation of all science students in the American Chemical Society's prize essay contest. Dr. W. L. Eikenberry of the East Stroudsburg State Normal School presided.

Teachers Need Ethics Code. The need of a national ethics code for teachers was stressed by Prof. Ward G. Reeder of Ohio State University, speaking before the American Association for the Advancement of Science. Prof. Reeder pointed out that teaching is the only profession still lacking such a code. A number of state teachers' associations have adopted codes of ethics but a national code would be of greater value to the profession, Prof. Reeder stated.

In arguing for a national code of ethics for teachers he said that "such code would give the profession of teaching more dignity and respect both on the part of the general public and of teachers; moreover, such code would do much to eliminate any unprofessional practices among teachers, since it would serve as a guide to the novice and unsophisticated practitioner and would be a silent warning to one who was tempted to act unprofessionally."—*Science Service*

Recent Books

Magnetism and Atomic Structure. E. C. STONER. E. P. Dutton & Co., New York, 1926. xiii + 371 pp. 13.5 × 22 cm. $5.00.

Do we chemists spend too much time organizing discussions as to whether oxidation and reduction should be interpreted with the aid of the electron concept, the while our physical brethren press on to the unexplored terrain which rightly belongs within the realms of our science? Some such query as this suggests itself after a perusal of the present volume. In it is treated the problem of atomic architecture and, as aid in the elucidation of the problem, the data of the modern theories of magnetism are utilized. Atomic architecture is essentially a chemist's problem, since therein must be found the keys to the solution of the chemist's problems of elementary properties and compound formation, valence, structure, and the like. And yet, how little of the work on atomic structure that has been achieved in the post-war period can be gracefully attributed to the chemist. The book under review, therefore, represents a call to arms to all vigorous young physical chemists who would fain share in the spoils of achievement. It is more than this, however; it is a veritable armory of weapons with which to advance to the assault. To many chemists the weapons are as unfamiliar and unwieldy as the lances of our forefathers. The spoils of victory already attained are such, however, as to prompt effort to the attainment of the necessary skill in their use.

The student will find in the book an account of magnetic phenomena and of their interpretation in terms of modern quantum theory. The treatment is selective and not exhaustive, no general treatment of ferromagnetism, for example, being given. Here, however, the chemist can learn how much has been achieved in the realm of paramagnetics, of the importance of quantitative measurement of the diamagnetism common to all matter. The Stern and Gerlach experiments on the moments of atoms and the experimental justification of quantum theory predictions are discussed and explained in detail. If the chemist would have inspiration for the task already ahead of him in this work let him turn first to Chapters XIV and XV and see what magnetism tells concerning the structure of the atoms, the magnetic properties of compounds, alloys, and crystals. "Permalloy" is one prize from such studies. He will surely take heart for the labors inherent in the first thirteen chapters.

HUGH S. TAYLOR

Practical Colloid Chemistry. WOLFGANG OSTWALD, DR. P. WOLSKI, AND DR. A. KUHN. Translated by I. NEWTON KUGELMASS, M.D., Ph.D., Sc.D., AND THEODORE K. CLEVELAND, Ph.D. E. P. Dutton and Company, New York, 1926. 4th edition. xvi + 191 pp. 10 × 20 cm. 22 illustrations. $2.25.

This is a translation of the fourth edition of the authors' "Kleines Praktikum der Kolloidchemie." There are 183 experiments distributed as follows: Preparation of Colloids, 47; Diffusion, Dialysis, and Ultrafiltration, 16; Surface Tension and Viscosity, 13; Optical Properties, 23; Electrical Properties, 7; Experiments with Gels, 30; Adsorption, 15; Coagulation, Peptization, and Related Phenomena, 32. In addition there is given a brief description of a number of commercial colloids and a scheme of colloid analysis.

Each section opens with a brief explanation of the phenomena to be studied and is followed by specific directions for carrying out the several experiments. It is

essentially a manual for beginners as most of the exercises involve the simplest procedures and but little special apparatus is required. Because of the number and variety of the exercises, teachers in a number of fields related to colloid chemistry will welcome the English translation of this standard German manual.

While the order of exercises may represent the procedure followed in Germany in the teaching of colloid chemistry, it is not the order used by colloid chemists who present the subject deductively. Thus the book starts off with the preparation of colloids, including peptization methods, and the phenomena of adsorption and peptization are not taken up until near the end of the volume. The user will not only choose the experiments but will modify the order to suit his needs. It is unfortunate therefore that the translators did not supply the index which the authors failed to furnish.

HARRY B. WEISER

Colloid Symposium Monograph. Vol. IV, Edited by HARRY BOYER WEISER, Chemical Catalog Company, New York City, 1926. 378 pp., 15 × 22 cm. $6.50.

The present volume contains the twenty-four papers presented at the Fourth Annual Symposium of Colloid Chemistry held at the Massachusetts Institute of Technology in June, 1926, and constitutes a very important addition to the growing literature on this subject. Wo. Ostwald's phrase "the chemistry of the neglected dimensions," surely no longer is applicable for the literature in this field grows at an amazing pace. The annual symposium serves to bring together the best of the American work of each year and each paper is subjected to the most critical discussion prior to publication. The material contained in the present volume covers the usual wide range and maintains the high standard set in previous years.

Whereas, a few years ago a list of American workers in this important field was rather limited and consisted of well-known names, the reviewer is gratified to see the appearance of more and more new names attached to important contributions. The papers included in this volume are as follows:

1. "A Survey of the Main Principles of Colloid Science," by James W. McBain.
2. "The Colloid Particle as Revealed by Catalytic Studies," by Hugh S. Taylor.
3. "The Water Equilibrium," by Wilder D. Bancroft.
4. "Making and Breaking Emulsions," by Wheeler P. Davey.
5. "Emulsification: A Study of Oil Soluble Emulsifying Agents," by Brian Mead and John T. McCoy.
6. "The Mechanism of Adsorption and of the Swelling of Gels," by Charles Terzaghi.
7. "Specific Ion Effects in the Behavior of Tanning Agents toward Collagen Treated with Neutral Salts," by K. H. Gustavson.
8. "Observations of the Colloidal Behavior of Aqueous Gelatin Systems," by Elmer O. Kraemer.
9. "Mass Action Effects in the Interaction of Gelatin and Acids," by W. K. Lewis and C. F. Daniell.
10. "The Helmholtz Double Layer Related to Ions and Charged Particles," by E. F. Burton.
11. "X-Rays and Colloids," by George L. Clark.
12. "The Structure of Ramie Cellulose as Derived from X-ray Data," by W. H. Dore and O. L. Sponsler.
13. "Organophilic Colloids," by G. Stafford Whitby.
14. "Colloidal Properties of the Surface of the Living Cell," by J. F. McClendon.
15. "The Function of Carbon Membranes in Osmosis," by F. E. Bartell and J. J. Osterhof.
16. "Electroendosmose through Wood Membranes," by Alfred J. Stamm.
17. "The Place of Adhesion in the Gluing of Wood," by Frederick L. Browne and T. R. Truax.
18. "Methods for Cutting and Differential Staining of Microscopic Sections of

Hardwood Glue-Joints," by Arthur I. Weinstein.

19. "Flocculation and Deflocculation of the Silver Halides," by S. E. Sheppard and R. H. Lambert.

20. "Pectin Jellies," by Miss G. Spencer.

21. "Cataphoresis, Electrical Charge, Critical Potential, and Stability of Colloids," by H. R. Kruyt Roodvoets and P. C. van der Willigen.

22. "The De-Inking of Paper," by Thomas R. Briggs and F. H. Rhodes.

23. "The So-called Adsorption of Ferric Oxide Hydrosol by Charcoal," by Arthur W. Thomas and Thomas R. LeCompte.

24. "Ionic Antagonism in Colloid Systems," by Harry B. Weiser.

JOSEPH H. MATTHEWS

A Text-Book of Inorganic Chemistry. Edited by J. NEWTON FRIEND, D.Sc., Ph.D., F.I.C.; Vol. VII. Part III. **Chromium and Its Congeners.** REECE H. VALLANCE, M.Sc., A.I.C. AND ARTHUR A. ELDRIDGE, B.Sc., F.I.C. J. B. Lippincott Co., Philadelphia, 1926. xxvi + 380 pp. 15 × 22 cm. $8.50.

This volume of the well-known series covers the elements chromium, molybdenum, tungsten, and uranium. The treatment is similar to that of the previously published volumes, giving a general discussion of the elements and of all their important inorganic compounds. The final chapter is devoted to the radioactivity of uranium and its disintegration products.

The literature has been well covered and the descriptive matter brought down to include recent investigations. The references are abundant. A table is included giving the dates of issue of all the important chemical journals published since 1800.

G. H. CARTLEDGE

Laboratory Experiments in Dairy Chemistry. LEROY S. PALMER, Ph.D. John Wiley and Sons. New York, 1926. xiii + 84 pp. 15 × 23 cm. $1.50 net.

The experiments in this manual are designed, as the author states in his preface, for the study of milk and its products from a biochemical standpoint.

The book is admirable in its conciseness. Tests of equipment and required material, as well as directions of procedure, are explicit and definite, minimizing the time required from both student and instructor for manual preparation. An excellent feature is a list of references following each experiment.

The laboratory work is not taken up from the analytical standpoint but teaches the use of viscosimeters, tensiometers, hydrogen-ion apparatus, and other equipment now employed in colloidal research.

The first chapters of the book take up chemical and physical properties of milk and its constituents. Interesting experiments are given on the microscopic appearance of milk, milk emulsions, and colloidal dispersions. The colloid particles are studied with the aid of the ultramicroscope. Skim milk is subjected to dialysis using collodion bags. The bags made according to the direction of the author give the best results of any ever prepared by the reviewers.

The chapters on butter and rennet coagulation aim to give an understanding, continuing the biochemical standpoint, of the properties that affect the commercial value of butter and milk in its relation to cheese and ice cream manufacture. Here the references touch also the same properties in their biological relationships.

The quantitative analysis of milk might have been made more complete by adding the analysis for lactose, calcium, and phosphorus.

In the appendix are found tables of indicators, buffers, specific heat of milk and milk products, determination of total solids of milk from specific gravity and percentage of fat, and other tables equally important.

The exercises outlined are based on six years' experience at the University of Minnesota, and the author believes that the experiments will "work" in the hands

of the average student. This very important fact has been verified in regard to some of the work by one of the reviewers.

The book should prove a valuable help to dairy departments, municipal milk inspectors, nutrition departments and all others interested in milk and milk products. It fills a long-felt need for a manual that gives emphasis to the colloidal and biochemical principles underlying the average routine dairy tests.

STATIE ERIKSON
R. N. MAXSON

The Preparation and Analysis of Organic Compounds. J. BERNARD COLEMAN AND FRANCIS ARNALL. P. Blakiston's Son & Co., Philadelphia, 1926. xvi + 352 pp. 13.5 × 21.5 cm. $4.00.

A book designed to place before the student a course of practical organic chemistry. It differs little in its scope from the usual conventional text-books written for presenting this subject to beginners and includes typical processes of laboratory synthesis with general methods of analysis both qualitative and quantitative. The series of preparations are quite comprehensive, and described in detail to aid the student, and prefaced with explanations regarding the theoretical processes involved. The authors have arranged their preparations in groups of related organic compounds, in this manner avoiding the method generally adopted of taking up the preparations in the order of increasing difficulty of application in the laboratory. The authors have introduced a scheme of organic analysis, somewhat original in conception in an elementary book of this character in which an endeavor has been made to systematize and organize an orderly arrangement of analytical procedure. This is an excellent feature and the method of treatment should be of assistance in stimulating a greater interest in the subject. Anything that can be done to systematize the subject of organic chemistry should be encouraged. Teachers of organic chemistry are somewhat inclined to place too much emphasis on the question of laboratory preparation in introductory courses and to give too little attention to system and organized technic. Just as important for success, as skill in manipulation or technic and familiarity with laboratory methods of synthesis, is the ability to analyze accurately mixtures of organic substances and establish the presence of characteristic groupings and to be able to work with small quantities of material. The importance of this is illustrated in the newer fields of biochemistry where we are called upon to carry out very careful chemical diagnosis in order to make progress. The synthesis is the final chemical achievement. The book serves a good purpose in emphasizing this particular phase of elementary instruction in organic chemistry.

TREAT B. JOHNSON

Physical Chemistry for Colleges. E. B. MILLARD, Associate Professor of Physical Chemistry, Massachusetts Institute of Technology. McGraw-Hill Book Co., Inc., New York. Second Edition. ix + 458 pp. 81 figures and 128 tables. 13.5 × 20 cm. $3.50.

The author's purpose, as stated in the preface of the original edition, has been "to bring before college students certain of the more important aspects of physical chemistry, together with accurate modern data which illustrate the applicability of its laws to the phenomena observed in the laboratory."

The second edition involves no fundamental changes and such changes as have been made are intended to bring certain topics up-to-date and to give a fuller presentation to keep pace with the relative increase in importance of such portions. To give an idea as to what changes this plan of the author has involved there is given below a list of chapter headings together with the increase which the second edition has added to each.

Chap. No.	Chap. heading	No. pages added by 2nd edition
I	Introduction, Determination of Atomic Weights	0
II	Laws of Gases	1
III	Liquid Substances	2
IV	Solids	13
V	Solutions—Ideal Solutions	4
VI	Ionized Solutes. Electrical Conductance	6
VII	Thermochemistry	1
VIII	Homogeneous Chemical Equilibria	1
IX	Heterogeneous Chemical Equilibria	3
X	Velocity of Chemical Reactions	3
XI	Physical Properties and Chemical Structure	0
XII	The Periodic Law	0
XIII	Radiochemistry and Radioactivity	1
XIV	Atomic Structure	2
XV	Surface Chemistry—Colloids	7
XVI	Electrochemistry—Electromotive Force	2

This will serve to give to any one familiar with the first edition an idea of the changes introduced by the second edition.

The book is well written and its value much increased by the problems added at the end of nearly every chapter and also by the large amount of well-chosen experimental data taken from the literature.

The reviewer does not see the desirability of making such little use in a book of this kind of such fundamental interpretations of chemical reactions as given by the laws of thermodynamics. Because an excellent text-book on this subject has appeared does not seem to justify relegating this important subject mostly to footnotes. The author has assumed that students using this book will have had adequate courses in physics and calculus. It appears to the reviewer that this subject should have been given more emphasis even at the expense, if necessary, of reducing the attention given to exploiting the more naive conceptions which the experimental data quoted by the author show to be only approximations.

J. C. W. FRAZIER

TO BE REVIEWED LATER

Applied X-Rays—Clark.

A Collection of Chemical Lecture Experiments—Davison.

Electro-Organic Chemistry—Brockman.

Evolution and Development of the Quantum Theory—Bligh.

The Hydrous Oxides—Weiser.

The New Heat Theorem—Nernst.

Practical Organic and Bio-Chemistry—Plimmer.

The Problem of Physico-Chemical Periodicity—Hedges and Myers.

A Text-Book of Organic Chemistry—Schmidt.

Laboratory Manual of Qualitative Analysis for Students of Pharmacy—Bradley.

My Work Book in General Science—Persing and Persing.

Second Year College Chemistry—Chapin.

Three Lectures on Atomic Physics—Sommerfeld.

Electrical Charges in Wire Cause Voltage Change. When a wire carries electricity, the electric charges within it are agitated by heat, and this agitation causes a minute fluctuation in the voltage, Dr. J. B. Johnson of the Bell Telephone Laboratories told the American Physical Society. This agitation results from the motion of the atoms which make up the wire, or other conductor, for even if it were at the lowest possible temperature, there is still some heat present, and they are, therefore, in motion.

By means of a powerful vacuum tube amplifier, similar to that used in radio receiving sets, Dr. Johnson has been able to magnify this voltage fluctuation and measure it. This discovery, he said, has an important bearing on the problem of "tube noise" in such amplifiers used in radio work.—*Science Service*

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